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PHYSICO-CHEMICAL FACTORS INFLUENCING CREAM RISING

I. VISCOSITY*

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The viscosity of milk has been considered (1) to be a factor influencing cream rising, but with the exception of the studies by van Dam and Sirks (2) and by Rahn (3) no data have been published attempting to correlate the viscosity with differences in the depth of the cream layer.

In the study by van Dam various substances (e.g., gum tragacanth, gelatin, starch, gum arabic, agar, and saleb, a material obtained by boiling Irish moss in linseed oil) were added to milk in suitable amounts so that in most cases there was little or no change in specific gravity. Gum tragacanth and saleb gave in general the best results. These substances caused a 15 to 25 per cent increase in the depth of the cream layer at 9°C. which was accompanied by an increase in viscosity of 25 per cent showing that with added substances there is some relation between viscosity and cream rising. Van Dam and Sirks have expressed the opinion that it is the milk plasma, not the fat, which has the chief influence on cream rising.

In Rahn's study gelatin and other hydrophilic colloids when added to milk increased both the cream layer and the viscosity in fairly close ratio. For example, the addition of 0.45, 1.35, and 1.8 per cent gelatin increased the viscosity 14.7, 67.0, and 110 per cent respectively with a corresponding increase of 33, 55, and 83 per cent in the depth of the cream layer. Although

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Rahn has concluded that variations in creamin are not due to variations in viscosity, his own data hardly w rrant this view.

The viscosity of milk is due to the combined ject of the constituents in true and in colloidal solution together with the emulsified fat. If one compares the viscosity of whey, skim milk, and whole milk with that of water, it is seen that water contributes from 30 to 50 per cent of the viscosity. Of the increase due to the milk solids, about 30 to 40 per cent is caused by the constituents in the whey, 70 to 90 per cent by the constituents in the skim milk and the remainder by the fat. The important fact is that most of the specific viscosity of milk is due to the solids-not-fat. Kobler (4) in fact, from whose data the above estimations are largely made, concluded that the viscosity of milk is greatly influenced by the casein.

There are a number of statements in the literature relative to the importance of the solids-not-fat in cream rising. Babcock (1) and Hunziker (5) have expressed such a view, the latter believing that the reduced cream volume usually found on pasteurized milk is due to a coagulation of the albumin.

A careful consideration of the whole subject of cream rising leads to the conclusion that the two outstanding factors involved in determining the volume of cream rising as a definite layer on a given lot of milk are, (*a*) the rapidity and completeness with which the fat globules rise, (b) the volume occupied by the risen fat globules. The fat globules rise in milk fundamentally because of the difference between the specific gravity of the fat and the plasma. Although the size of the fat drops and the extent of their association (3) no doubt contribute a great deal to the rapidity and exhaustiveness of creaming in a given length of time, they can not be the only factors involved. It is certain that there is as yet no basis for assuming that either the size of the fat globules or their clumping determines the volume occupied by the risen fat. In making these assertions conditions involving a uniform fat content are of course assumed.

The present study was undertaken to determine the extent to which the viscosity of milk is related to the depth of the cream layer on both raw and pasteurized milk. The data secured also

throw light on the relative importance of viscosity and size of fat globules in cream rising as met under normal conditions. Of special interest are the results showing the distribution of fat between the cream and skim milk layers.

EXPERIMENTAL

Methods of procedure

The milk used was secured from the University herd. Uniform quality was approached as nearly as possible by using milk from the same cows in all experiments where mixed milk was used. In these cases the milk represented two-thirds Holstein milk and one-third Jersey-Guernsey. For the breed experiments, milk from the Jerseys and Guernseys represented one standard and milk from Holsteins the other. It was not feasible to control any possible effect of the stage of lactation. This effect could not have been significant, however, because a comparison of the viscosity of the milk and stage of lactation of 8 cows, 4 Holstein and 4 Guernsey, whose lactation period ranged from six days to seven hundred fifty-one days, showed no relation between the two factors.

Except in the case of data for the milk from individual animals, all milk was standardized to a fat content of 3.5 per cent.

Pasteurization was carried out by the holding method. When the volume of milk warranted it, a 150-gallon "Jensen Cream Ripener" was used; otherwise the milk was placed in shotgun cans and immersed in a large vat of hot water. Heating was continued for thirty minutes after the milk had attained the desired pasteurizing temperature. Cooling was brought about as quickly as possible by means of a vat of cold water.

Cream layers were measured on samples of milk placed in 200 cc. flat bottom, graduated cylinders. Usually the milk was at a temperature of 26°C. when placed in the cylinders. Four cylinders were used for each sample, two of which were cooled to 0°C. and the other two to 9° to 10°C. These temperatures were maintained for twenty-four hours, after which the depth of the cream was measured with dividers. One-half of the average reading was recorded as the percentage of cream.

In a number of cases an estimate was made of the distribution of fat between the cream and skim milk layer. For this purpose cylinders were employed having a hole about 3 mm. in diameter bored in the side a few millimeters from the base. These were kept stoppered until the end of the creaming period when the stopper was removed and the skim milk drawn off sowly to within ¼ inch of the cream layer. The percentage of fat in this layer was determined directly, using the Babcock test. The approximate percentage of fat in the cream layer was calculated by the formula,

$$C^* = \frac{x - \frac{(100 - y)z}{100}}{z} \times 100$$

where C = percentage fat in cream layer
x = percentage fat in the milk
y = percentage cream
z = percentage fat in skim layer

Specific gravity was determined by the lactometer (United States Dairy Division type). Solids-not-fat were calculated from the tables of Shaw and Eckles (6).

Hydrogen ion concentrations were determined potentiometrically using the Bailey electrode.

Viscosities were measured by the MacMichael viscosimeter, using a disc bob and a "00" torsion wire. The cup was not rotated; instead, the disc was rotated somewhat as in the Doolittle (7) method, as follows. The disc was first turned to the left one revolution and then allowed to rotate back through the milk until a maximum deflection was reached. This reading, subtracted from the reading obtained in air alone was taken as the comparative viscosity of the milk. In order that the results could be calculated in terms of centipoise units the instrument was calibrated by means of sugar solutions and a reference curve constructed. Although the method employed for the viscosity work was arbitrary, the results could thus be expressed in units such that the data can be verified (or otherwise) by other workers

* This formula does not give strictly accurate results because it ignores the specific gravity of the skim milk and cream.

using any instrument from which similar calculations can be made.

Results

a. Influence of breed. The influence of breed on the viscosity of milk was first determined on a composite twenty-four-hour sample from each of 37 cows, representing 2 Ayrshire, 5 Jersey, 11 Guernsey, and 19 Holsteins. The average data for the breeds are shown in table 1.

These data do not indicate any relation between the hydrogen ion concentration and viscosity of milk, but there is a relation shown between both the fat content and solids-not-fat and viscosity. Inasmuch as the viscosity range is accompanied by

TABLE 1

The composition, viscosity, and other property of milk from different breeds of cows

BREED	FAT	SOLIDS-NOT-FAT	SPECIFIC GRAVITY	pH	VISCOSITY		
					At once at 25° C.	At once at 0° C.	After twenty-four hours at 0° C.
	per cent	*per cent*			*cp.*	*cp.*	*cp.*
Jersey	5.62	9.64	1.034	6.47	2.77	5.67	5.71
Guernsey	4.77	9.37	1.0336	6.44	2.37	5.18	5.44
Ayrshire	4.62	9.13	1.0331	6.70	2.39	5.16	5.88
Holstein	3.41	8.81	1.0325	6.44	1.90	4.57	4.63

a wider range of fat than of solids-not-fat, the data suggest that the latter exerts the greater effect. In the case of market milk, however, where creaming variations are of special importance, the percentage of fat has practically no bearing on these variations because of the almost universal practice of standardization. The relation of viscosity to creaming variations must accordingly be sought in the effects exerted by the size of fat globules and by the solids-not-fat.

The relation of fat-globule size, or more correctly the relative number of fat globules, to viscosity is illustrated best by the well-known effect of homogenization which increases the viscosity very greatly. While this is an extreme case not met in market milk,

it suggests that there may be sufficient breed difference with respect to the relative size of the fat globules to be a factor in creaming.

b. Relative effect of size of fat globules and content of solids-not-fat on viscosity and creaming. The opinion is held (8) that the milk from the Jersey and Guernsey breeds creams more easily than that of the Holsteins and Ayrshires because the larger fat globules have a greater mass in proportion to their surface. This hypothesis was tested by two experiments as follows. In the first experiment Holstein skim milk was standardized to 3.5

TABLE 2

Relative influence of solids-not-fat and size of fat globules on viscosity and creaming

EXPERIMENT NUMBER	SOURCE OF PLASMA	SOURCE OF FAT GLOBULES	SOLIDS-NOT-FAT	PROPERTIES AT 0°C.		PROPERTIES AT 9° TO 10°C.	
				Viscosity after twenty-four hours	Volume of cream	Viscosity after twenty-four hours	Volume of cream
			per cent	*cp.*	*per cent*	*cp.*	*per cent*
1	Holstein	Holstein	8.59	5.32	11.30	2.89	6.80
	Holstein	Jersey-Guernsey	8.61	5.38	13.01	3.13	9.30
	Jersey-Guernsey	Jersey-Guernsey	9.35	6.05	17.40	3.36	12.80
	Jersey-Guernsey	Holstein	9.30	5.93	16.51	3.58	11.30
2	Holstein	Holstein	8.79	5.24	12.41	2.93	7.51
	Holstein	Jersey-Guernsey	9.11	5.87	11.81	3.01	6.41
	Jersey-Guernsey	Jersey-Guernsey	9.61	6.41	16.80	3.25	14.51
	Jersey-Guernsey	Holstein	9.44	6.19	16.71	3.77	10.91

per cent fat with freshly separated cream (55 per cent fat) from Jersey-Guernsey milk, and an analogous milk prepared from Jersey-Guernsey skim milk and Holstein cream. The properties of these milks were compared with those of unaltered Holstein and Jersey-Guernsey milk except as was necessary to bring the fat content to 3.5 per cent. In the second experiment all the milks were prepared from skim milk and cream. The results are given in table 2. They show clearly that with a uniform fat content such variation in the size of the fat globules as results from breed differences is relatively unimportant in determining

either viscosity or creaming. On the other hand, the data show a direct relation between the concentration of solids-not-fat and viscosity; the data also indicate a close relation between creaming and viscosity, but the relationship does not appear to be an absolute one. For example, in both experiments practically as good cream layers were obtained at 9° to 10°C. with the Jersey-Guernsey plasma as at 0° with Holstein plasma, although the viscosity in the former case averaged about 3.5 and in the latter about 5.4. A closer relationship between viscosity and creaming

TABLE 3

Viscosity, creaming, and fat distribution between skim milk and cream of raw and pasteurized milk of uniform composition

EXPERIMENT NUMBER	TEMPERATURE OF PASTEURIZATION	PROPERTIES AT 0°C.				PROPERTIES AT 12°C.			
		Viscosity after twenty-four hours	Cream volume	Concentration fat in skim	Approximate concentration fat in cream	Viscosity after twenty-four hours	Cream volume	Concentration fat in skim	Approximate concentration fat in cream
	°C.	*cp.*	*per cent*	*per cent*	*per cent*	*cp.*	*per cent*	*per cent*	*per cent*
1	Raw	5.45	14.8	0.34	21.7	3.12	11.6	1.12	21.6
	60	5.57	13.6	0.23	24.2	3.03	11.7	0.85	23.5
2	Raw	5.34	16.4	0.27	20.0	2.93	11.7	1.20	20.9
	62	4.80	14.9	0.35	21.5	2.89	10.8	0.90	25.0
3	Raw	4.73	15.4	1.00	17.2	3.10	10.5	1.50	20.6
	65	4.45	13.5	1.20	18.2	2.93	10.0	1.22	24.8
4	Raw	5.02	15.9	0.52	19.3	2.75	9.8	1.52	21.7
	67	4.28	11.1	1.30	21.1	2.87	9.0	1.42	24.5

is seen when comparing the cream volume and viscosity at 0°C. with the same data at 9° to 10°C. The percentage decline at the higher temperatures is not identical for both viscosity and cream volume, but is as uniform for each factor as could be expected. Calculation shows an average decrease in viscosity of 43.8 per cent accompanied by an average decrease of 32.5 per cent in cream volume.

c. Viscosity change as a factor in the influence of pasteurization on creaming. The results obtained with raw milk suggested

that the detrimental effect of pasteurization on creaming might be explained, at least in part, by changes in viscosity.

Two groups of experiments were conducted, the first with mixed

TABLE 4

Viscosity, creaming, and fat distribution between skim milk and cream, of raw and pasteurized milk of uniform fat content and varying content of solids-not-fat and varying size of fat globules

Experiment number	Temperature of pasteurization	Solids-not-fat*	Fat globules†	Properties at 0°C.				Properties at 12°C.			
				Viscosity after twenty-four hours	Cream volume	Concentration fat in skim	Approximate concentration fat in cream	Viscosity after twenty-four hours	Cream volume	Concentration fat in skim	Approximate concentration fat in cream
	°C.	per cent		cp.	per cent	per cent	per cent	cp.	per cent	per cent	per cent
1	Raw	8.71	Small	4.05	14.3	1.00	18.4	2.54	13.4	1.37	17.3
	62	8.71	Small	3.94	11.0	1.40	20.5	2.43	8.5	1.87	19.9
	Raw	9.47	Large	4.84	17.0	0.37	18.8	2.89	14.3	0.90	19.1
	63	9.47	Large	4.62	11.0	1.30	21.3	2.89	7.3	2.00	22.6
2	Raw	9.81	Large	4.22	16.4	0.90	16.8	2.63	7.0	1.97	23.8
	62	9.81	Large	4.10	11.4	1.20	21.3	2.59	6.4	1.87	27.3
	Raw	9.34	Small	4.28	14.3	1.00	14.5	2.66	5.1	2.45	23.1
	63	9.34	Small	4.28	2.0	3.10	22.4	2.47	1.5	2.97	38.3
3	Raw	9.19	Small	4.14	15.3	1.60	14.0	2.24	8.5	2.10	18.6
	63	9.19	Small	4.03	2.8	2.95	22.6	2.32	2.9	2.90	23.6
	Raw	8.99	Large	3.70	11.8	1.70	16.9	2.01	5.8	2.35	22.2
	63	8.99	Large	3.54	2.0	2.90	32.9	2.19	2.3	2.75	35.3
4	Raw	8.69	Small	4.22	10.8	2.50	11.8	2.32	7.1	2.55	15.9
	65	8.69	Small	3.94	1.5	3.30	16.7	2.19	1.4	3.05	35.1
	Raw	9.11	Large	4.10	6.4	2.70	15.2	2.43	6.0	2.60	17.6
	66	9.11	Large	4.45	1.5	3.30	16.7	2.89	1.5	3.20	23.2

* The lower solids-not-fat represents Holstein plasma, and the higher Jersey-Guernsey plasma.

† Small fat globules represent Holstein cream and large fat globules Jersey-Guernsey cream.

milk in vat lots and the second in smaller lots using milk in which the solids-not-fat and size of fat globules were varied as in part (*b*). The temperatures of pasteurization varied from 60° to

67°C. for the different lots of mixed milk and from 62° to 65.8°C. for the milk with varying content of solids-not-fat. In both experiments the fat content was adjusted to 3.5 per cent. The data for the first group of experiments are summarized in table 3, and for the second group of experiments in table 4. An average of all data collected on raw and pasteurized milk is given in table 5. In this average are included a number of other experiments not reported in this paper in which a study was made of the effect of various milk plant operations on cream rising.

When examining the properties of the milk at 0°C. as shown in tables 3, 4, and 5, it appears as though the decrease in cream volumes resulting from pasteurization is more or less related to a lowered viscosity. This apparent relation becomes much less

TABLE 3

Average relation found between viscosity, creaming, pasteurization and distribution of fat between skim milk and cream

NUMBER OF SAMPLES	TEMPERATURE OF CREAMING	TREATMENT	VISCOSITY AFTER TWENTY-FOUR HOURS	CREAM VOLUME	CONCENTRATION FAT IN SKIM	APPROXIMATE CONCENTRATION FAT IN CREAM
	°C.		cp.	per cent	per cent	per cent
46	0	Raw	5.10	15.6	0.76	18.3
16	0	Pasteurized	4.47	9.1	1.58	22.7
46	9–12	Raw	3.01	10.6	1.45	20.8
16	9–12	Pasteurized	2.71	7.1	1.84	25.2

significant when examining the data for milks with varying content of solids-not-fat and having a different initial viscosity. The relationship practically disappears for the milk creamed at the higher temperature where many cases occurred showing no effect of pasteurization on viscosity and great effect on creaming. It is true that the average of all the data collected (table 5) indicates a general relationship between viscosity and creaming as affected by pasteurization. Calculation shows, however, that while there is no correspondence between the percentage decline in viscosity and the percentage loss in cream volume, there is a rather close proportion between the two when comparing the results at the two creaming temperatures. The ratio between viscosity decrease and cream volume loss was 1:29.5 at 0°C. and 1:31.5 at

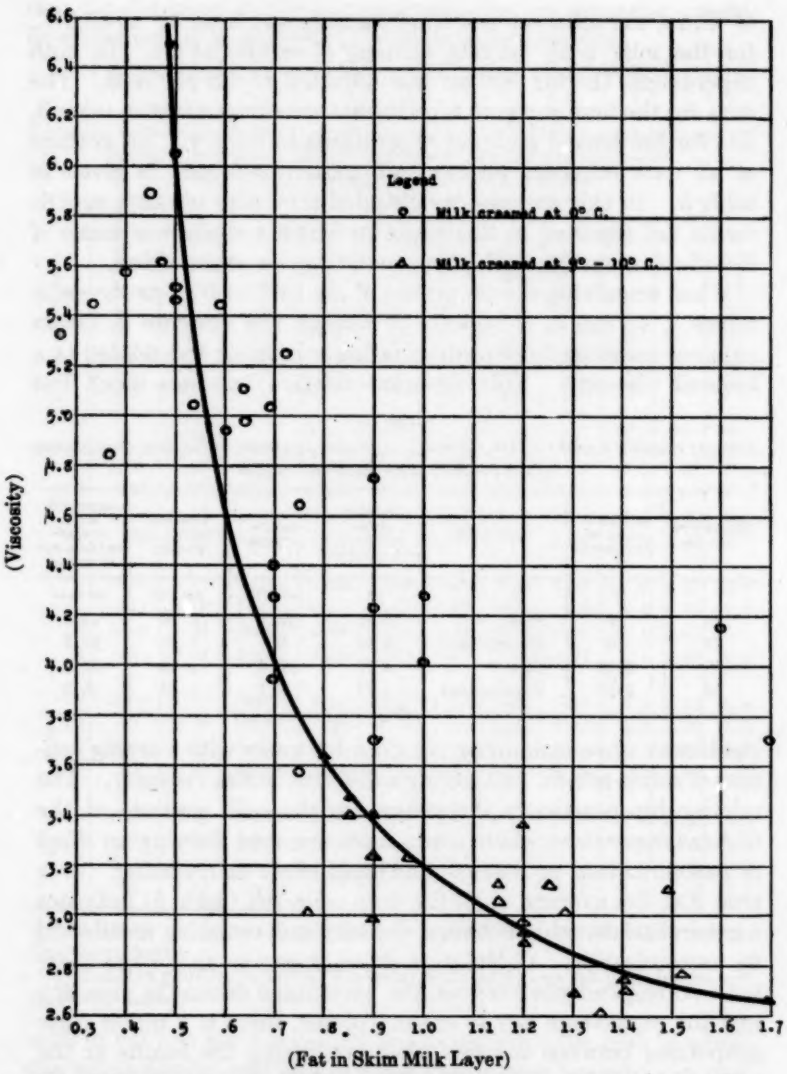

FIG. 1. RELATION BETWEEN VISCOSITY OF RAW WHOLE MILK AND THE PERCENTAGE OF FAT IN THE SKIM MILK LAYER AFTER CREAMING

9° to 12°C. However, these ratios are too wide to warrant the conclusion that viscosity is a major index of the detrimental effect of pasteurization on cream rising.

d. Influence of pasteurization on fat distribution in skim milk and cream layers. Much more significant are the data on the distribution of fat between the cream and skim milk layers. In a great majority of cases a loss in cream volume due to heating was accompanied by a higher percentage of fat in the skim milk, and in every instance by a higher percentage of fat in the cream. This shows clearly that losses in cream volume because of heating the milk are often due to less exhaustive creaming and particularly to a closer packing of the fat globules in the cream layer.

A complete explanation of the cause of the less exhaustive creaming awaits further study. Figure 1 shows that there is some relation between this result and the viscosity in the case of raw milk. The points on the chart are taken in part from the data in tables 3 and 4 and in part from other experiments not reported. While the points do not fall on the curve as closely as may be desired, the general relationship is shown very definitely. A similar correlation does not exist for pasteurized milk.

The causes underlying the closer packing in the cream layer are also little understood. Our results are similar to those obtained by Weinlig (9). He believes that the increased concentrations of fat in the cream layer which he observed after pasteurizing milk at temperatures above 63° to 64°C. are due to changes in the composition of the membrane material around the fat globules, giving rise to a decreased tenacity. The problem, however, requires further study.

DISCUSSION

The results of this study show clearly that the plasma colloids are a much more important factor in determining cream volumes than are the fat globules themselves when studying milk with a uniform fat content. Inasmuch as the specific viscosity of milk is due largely to the plasma colloids it is not surprising that the cream volume rising on raw milk is affected by such factors as influence the viscosity of the plasma. Certainly the difference

in viscosity of milk at 0°C. compared with 9° to 12°C. is sufficient to account for the variations in the cream layer at the two temperatures. However, the variations in the depth of the cream layer at the same creaming temperature are not accounted for wholly by differences in viscosity.

The detrimental effect of pasteurization on cream volumes is only explained in part by viscosity changes. The decrease in viscosity of pasteurized milk is too small to account for the decrease in depth of the cream layer when compared with raw milk. If viscosity were a true index of cream rising the great increase in viscosity accompanying a lowering of the creaming temperature would be expected to overcome the slight decrease in viscosity due to the heat. On the contrary the results show that while the viscosity of pasteurized milk is still relatively high at 0°C., in comparison with the viscosity at 9° to 12°C. the cream volume at lower temperatures are not proportionate to the higher viscosity at that temperature. It is therefore obvious that pasteurization effects are not explainable on the basis of viscosity.

The relation of the concentration of plasma solids to cream volumes on raw milk is shown very strikingly by the experiments on milk with a uniform fat content in which cream and plasma were interchanged to give different levels of solids-not-fat and a different relative size of the fat globules. When the solids-not-fat were higher a better cream layer resulted regardless of the relative size of the fat-globules. It is recognized that the data show some favorable influence due to larger fat globules, but it is not very great. It is clear, however, why the breed differences in cream layers on raw milk are so striking, especially when comparing Holstein with Jersey or Guernsey milk. In the former lower plasma solids are accompanied by both relatively small fat globules and lower fat content while in the latter higher plasma solids are associated with both larger globules and more fat. Pasteurization, however, tends to minimize these differences. For pasteurized milk just as poor cream layers are apparently obtained in milk with the higher plasma solids as with the lower.

The distribution of fat between the skim milk and cream layers

of pasteurized milk is very suggestive for a further study of the fundamental factors causing losses in cream volumes. It was pointed out in the introductory paragraphs that one of the two important general factors determining the depth of cream layers is the volume occupied by the risen fat globules. This factor is seen in a very striking manner in our experiments showing that there is a distinctly closer packing of the fat globules in the cream which rises on pasteurized milk. It is of interest to note, also, that the cream which formed in many of our experiments was richer in fat than the standard 18 per cent product distributed by many dairies as cream.

CONCLUSIONS

1. The volume of cream rising on raw milk of uniform fat content is determined largely by the content of solids-not-fat in the plasma.

2. The specific viscosity of raw milk is determined in large measure by the content of plasma solids and by the temperature at which the plasma is held.

3. The viscosity of raw milk is a good index of its creaming ability and can be used as an explanation of changes in cream layers caused by the temperature of creaming or the concentration of plasma solids in the milk.

4. Viscosity is only a minor factor in determining the cream layers on pasteurized milk; the fundamental factors having an adverse effect remain to be determined.

5. The deterimental effect of pasteurization on cream volumes is accompanied by (*a*) less exhaustive creaming and (*b*) closer packing of the fat globules in the cream layer. Neither of these effects are explainable by viscosity changes. In raw milk, however, there is a general relation between viscosity and exhaustiveness of creaming.

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THE MAINTENANCE REQUIREMENT OF CATTLE FOR PROTEIN, AS INDICATED BY THE FASTING KATABOLISM OF DRY COWS*[1]

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The study here reported is based on experiments with fasting, dry cows, and was designed primarily to add to the knowledge of the energy metabolism of cattle. The collection and analysis of the excreta during fast, however, yielded data of significance in relation to protein requirements, and these constitute the basis of the present paper. The results of the heat measurements and of the gaseous exchange will be treated elsewhere.

OUTLINE OF THE INVESTIGATION

The schedule of experimental treatment will be found in table 1.

Four dry Jersey cows were used as subjects in this investigation and are designated nos. 874, 885, 886 and 887. These are the same animals as were used in the experiments on "The maintenance requirement of dry cows" which have been already reported (2). The fasting experiments with these animals were conducted during the same years as the maintenance experiments, the periods of fast following the periods in which the animals received maintenance rations in respect to energy. In experiment 221D, 1920, cows 885 and 886 were used, each being six years old. In experiment 221E, 1921, cow 885 was used. In experiment 221F, 1922, cow 874, six years old, and

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[1] This series of experiments was planned by the late Dr. H. P. Armsby, and conducted under the immediate direction of Mr. J. A. Fries, by Messrs. W. W. Braman, D. C. Cochrane, Max Kriss, C. D. Jeffries, R. M. Meredith and W. J. Sweeney.

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TABLE 1

Schedule of starvation and preceding maintenance periods

EXPERIMENT AND ANIMAL NUMBER	FEEDING PERIODS PRECEDING FAST						STARVATION PERIODS			
	Dates	Daily ration				Daily gain of nitrogen by body	Duration of fast	Date and time of offering last feed	Intervals of time represented by excreta collected	Dates of calorimeter measurements
		Hay	Grain	Nitrogen						
				Total	Apparently digested					
		kgm.	*kgm.*	*gms.*	*gms.*	*gms.*	*days*			
221D—886	January 25 to March 22, 1920	1.745	2.614	95.6	71.5	+6.7	3	March 22, 5 p.m.	March 22, 8 a.m. to March 25, 6 p.m.	March 23 to 25
885	February 8 to April 5, 1920	1.779	2.668	97.3	75.7	+4.5	3	April 5, 5 p.m.	April 5, 8 a.m. to April 8, 6 p.m.	April 6 to 8
221E—885	February 12 to March 11, 1921	1.580	2.360	88.3	68.8	+4.5	6	March 11, 5 p.m.	March 11, 8 a.m. to March 17, 6 p.m.	March 15 to 17
221F—874	January 7 to February 1, 1922	1.830	2.744	97.4	73.1	+2.1	9	February 1, 6 a.m.	February 1, 8 a.m. to February 10, 8 a.m.	February 7 to 9
887	March 1, to March 22, 1922	1.650	2.474	89.0	68.5	−3.8	9	March 22, 6 a.m.	March 22, 8 a.m. to March 31, 8 a.m.	March 28 to 30

cow 887, five years old, were used. The length of the fasting periods was 3 days in experiment 221D, six days in experiment 221E, and nine days in experiment 221F. The animals were kept on approximately maintenance rations of alfalfa hay and a grain mixture for at least three weeks preceding the fasting experiments. The grain mixture consisted of 30 parts by weight of wheat bran, 30 parts of ground oats, 30 parts of corn meal and 10 parts of old process linseed meal.

During the fasting experiments, and the preceding maintenance periods, the animals were kept in the Institute barn, except during the last two days of each experimental period, which were passed in the calorimeter. The animals were offered water at 8:00 a.m. in the barn, and at 7:00 a.m., in the calorimeter.

Feces and urine were collected as a mixture, the daily collection being at 8:00 a.m., in the barn, and at 6:00 p.m., in the calorimeter. During the last few days of the fast, in experiments 221E and 221F, the feces were of such solid consistency that it was practicable, in some cases, to make an approximately complete separation of the urine from the feces by decanting, and straining the urine through cheesecloth. Such a separation was made of the excreta collected during thirty-four hours preceding the last day of the fast in experiment 221E, and during the last four days of the fast in experiment 221F. In the tables the data relating to these separated excreta are designated by the letters U and F following the weights of the fresh urine and feces.

The feces-and-urine mixtures and the separated excreta were subjected to the usual complete analysis, but only the dry matter, crude fiber and nitrogen will be here considered. Nitrogen was determined in the fresh feces, and feces-and-urine mixtures, by König's method, and in the urine by the Kjeldahl method.

THE EFFECT OF FASTING ON THE EXPERIMENTAL ANIMALS

The animals showed no physical ill-effects of the fasting. Apparently they lost the natural craving for feed at about the

third day. Close observation showed no unusual actions other than the failure to ruminate, and the rather frequent moistening of the muzzle with the tongue.

At the close of the fasting period, alfalfa hay was offered the animals. In each case after taking but a few mouthfuls the

TABLE 2

Daily record of live weight and of water drunk during fast

EXPERIMENT, ANIMAL, AND PERIOD	DATE	LIVE WEIGHT	WATER DRUNK	EXPERIMENT, ANIMAL, AND PERIOD	DATE	LIVE WEIGHT	WATER DRUNK
	1920	*kgm.*	*kgm.*		*1922*	*kgm.*	*kgm.*
221D				221F			
886-IV	March 22		11.0	874-III	February 1		12.8
	March 23	419.0*	0.0		February 2	417.2*	0.0
	March 23	416.9†	—		February 3	409.6*	0.0
	March 24		0.0		February 4	404.0*	7.2
	March 25	402.3‡	0.0		February 5	404.8*	0.0
					February 6	400.0*	4.0
885-IV	April 5		10.4		February 7	401.0*	0.0
					February 7	396.9†	—
	April 6	422.4*	0.8		February 8	—	8.3
	April 6	420.9†	—		February 9	398.7‡	1.2
	April 7		2.7		February 10	391.7*	0.0
	April 8	415.9‡	5.2				
	1921			887-III	March 22		15.4
221E					March 23	319.0*	0.0
885-III	March 11		8.4		March 24	312.4*	0.0
	March 12	429.8*	5.2		March 25	307.4*	4.6
	March 13	426.4*	5.9		March 26	305.3*	9.3
	March 14	428.4*	0.0		March 27	308.0*	3.0
	March 15	422.0*	3.2		March 28	304.6*	0.0
	March 15	424.2†	—		March 28	303.9†	—
	March 16		2.0		March 29	—	0.4
	March 17	417.6‡	4.4		March 30	294.9‡	7.4
					March 31	290.1*	0.0

* Before drinking, at 8:00 a.m.
† At 1:00 p.m.
‡ At 6:00 p.m.

animals lay down. After about an hour more hay was taken, and within twenty-four hours the animals were eating normally.

DAILY RECORD OF LIVE WEIGHTS AND WATER DRUNK

In table 2 the daily live weights of the animals, and the water drunk during the fast, have been collected for reference. The

animals could not be weighed while in the respiration calorimeter, but were weighed before entering and upon leaving the chamber. Attention is directed to the wide variation in the daily amounts of water drunk during the fast. With one exception (cow 885) the animals refused to drink on the first and second days of the fast.

THE DAILY EXCRETION OF FECES AND URINE BY THE FASTING COWS

Table 3 presents data relative to the daily excretion of feces and urine. These data exhibit great irregularity, and render obvious the difficulty of getting a true picture of the daily excretion of fasting cows. For example, in experiment 221F, cow 874 excreted neither urine nor feces during the twenty-four hours ending February 9, 6:00 p.m., while during the following fourteen hours (ending February 10, 8:00 a.m.) she excreted 7.9 kgm. of urine and feces, containing 81.2 grams of total nitrogen, of which 66.9 grams were contained in the urine. This amount of urinary nitrogen is greater than the amount of nitrogen excreted in both urine and feces during any one of the preceding six days, and, if computed per day, would be greater than that excreted in both urine and feces during the three preceding days combined. This demonstrates the futility of attempting to picture the daily decrease of nitrogen excretion from data secured by arbitrarily separating the excretion into twenty-four-hour periods, and shows the necessity, in accurate work, of catheterizing the subjects at the beginning and at the close of an experimental period.

Of especial interest is the persistance of crude fiber in the feces of cows 874 and 887 during the nine-day fasting periods. From this it is obvious that even during nine days of starvation the alimentary tract is not completely freed from feed residues, though the amounts of crude fiber eliminated during the latter part of the fasting periods are comparatively slight.

THE PROTEIN KATABOLISM OF FASTING

The nitrogen of the urine during short fasting periods must be considered to contain a small and rapidly diminishing quota

TABLE 3

The daily excretion of feces and urine by the fasting cows

EXPERIMENT, ANIMAL, AND PERIOD	DATE AND TIME OF ENDING DAILY COLLECTION	TIME COVERED BY COLLECTION	TIME INTERVAL BETWEEN LAST FEEDING AND END OF COLLECTION		WEIGHT OF FRESH EXCRETA	DRY MATTER OF EXCRETA*		CRUDE FIBER		NITROGEN		
								Dry matter basis	Weight	Fresh basis	Urine and feces separated	Urine and feces mixed
	1920	*hours*	*days*	*hours*	*kgm.*	*per cent*	*grams*	*per cent*	*grams*	*per cent*	*grams*	*grams*
221D												
886–IV	March 23, 8 a.m.	24	0	15	11.124	12.75	1,418.1	29.49	418.2	1.02		113.0
	March 23, 6 p.m.	10	1	1	4.863	11.97	581.9	31.61	183.9	0.76		36.7
	March 24, 6 p.m.	24	2	1	4.460	10.38	463.0	27.71	128.3	1.46		65.2
	March 25, 6 p.m.	24	3	1	2.823	16.17	456.5	34.79	158.8	1.28		36.2
885–IV	April 6, 8 a.m.	24	0	15	12.274	11.77	1,444.0	31.57	455.8	0.83		102.2
	April 6, 6 p.m.	10	1	1	5.968	13.40	799.9	35.62	284.9	0.49		29.3
	April 7, 6 p.m.	24	2	1	3.252	8.89	289.2	19.37	56.0	1.98		64.3
	April 8, 6 p.m.	24	3	1	0.826†	21.49	177.5	34.49	61.2	0.63		5.2
	1921											
221E												
885–III	March 12, 8 a.m.	24	0	15	9.150	12.97	1,186.3	32.19	381.9	0.86		78.2
	March 13, 8 a.m.	24	1	15	4.416	9.07	400.7	26.19	104.9	1.51		66.7
	March 14, 8 a.m.	24	2	15	1.200	22.56	270.7	36.90	99.9	0.49		5.9
	March 15, 8 a.m.	24	3	15	4.470	12.11	541.5	29.82	161.5	1.53		68.3
	March 15, 6 p.m.	10	4	1	1.518 U.	—	—	—	—	1.85	28.0	32.4
					0.240 F.	10.64	25.5	29.90	7.6	1.83	4.4	
	March 16, 6 p.m.	24	5	1	1.804 U.	—	—	—	—	1.47	26.5	28.5
					0.126 F.	12.66	16.0	—‡	—‡	1.55	2.0	
	March 17, 6 p.m.	24	6	1	4.790	9.00	431.0	27.69	119.4	1.19		56.8
	1922											
221F												
874–III	February 2, 8 a.m.	24	1	2	7.860	17.15	1,348.0	25.61	345.2	1.08		85.0
	February 3, 8 a.m.	24	2	2	5.160	14.28	737.0	29.23	215.4	1.46		75.4

	February 4, 8 a.m.	24	3	2	3.800	14.71	559.0	31.24	174.6	1.20		45.6
	February 5, 8 a.m.	24	4	2	3.110§	4.67	145.1	—	—	1.01		31.3
	February 6, 8 a.m.	24	5	2	3.000	11.20	336.0	32.22	108.3	0.97		29.1
	February 7, 8 a.m.	24	6	2	1.978 U. 0.902 F.	5.59 19.60	110.6 177.0	— 33.39	— 59.1	1.43 1.19	28.2 10.7	38.9
	February 7, 6 p.m.	10	6	12	1.670 U. 0.490 F.	6.41 22.29	107.1 109.0	— 34.64	— 37.8	1.49 0.92	24.9 4.5	29.4
	February 8, 6 p.m.	24	7	12	2.700 U. 0.260 F.	6.23 21.89	168.1 57.0	— 35.70	— 20.3	1.59 0.84	42.8 2.2	45.0
	February 9, 6 p.m.	24	8	12	0.000	—	0.0	—	—	—	0.0	00.0
	February 10, 8 a.m.	14	9	2	6.300 U. 1.630 F.	4.02 18.67	253.0 304.0	— 37.60	— 114.3	1.06 0.88	66.9 14.3	81.2
887-III	March 23, 8 a.m.	24	1	2	13.830	10.85	1,500.0	26.72	400.8	0.83		114.7
	March 24, 8 a.m.	24	2	2	4.720	11.43	539.0	28.70	154.7	1.43		67.4
	March 25, 8 a.m.	24	3	2	1.860	15.59	290.0	33.46	97.0	1.25		23.3
	March 26, 8 a.m.	24	4	2	5.240	10.45	548.0	28.37	155.5	1.47		77.0
	March 27, 8 a.m.	24	5	2	3.570	8.54	305.0	28.47	86.8	1.33		47.6
	March 28, 8 a.m.	24	6	2	2.112 U. 2.118 F.	2.49 13.18	52.6 279.0	— 38.66	— 107.9	1.00 0.93	21.1 19.6	40.7
	March 28, 6 p.m.	10	6	12	1.124†	10.01	113.0	39.77	44.9	0.91	10.3	10.3
	March 29, 6 p.m.	24	7	12	6.088 U. 0.482 F.	2.52 14.42	153.4 69.0	— 41.34	— 28.5	0.66 0.74	40.1 3.6	43.7
	March 30, 6 p.m.	24	8	12	3.462 U. 1.564 F.	3.52 15.80	121.8 247.0	— 41.95	— 103.6	0.93 0.77	32.0 12.1	44.1
	March 31, 8 a.m.	14	9	2	3.645 U. 0.480 F.	1.62 13.56	59.1 65.0	— 42.20	— 27.4	0.59 0.60	21.5 2.9	24.4

Note: U. denotes urine; F. denotes feces.

* As determined, uncorrected for loss on drying.

† All feces.

‡ Disregarded; quantity negligible.

§ All urine.

TABLE 4

Average daily excretion of feces and urine by the fasting cows (based on data of table 3)

EXPERIMENT, ANIMAL, PERIOD	DURATION OF FAST	COLLECTIONS OF EXCRETA UPON WHICH AVERAGE PER DAY IS BASED	FRESH WEIGHT	DRY MATTER	CRUDE FIBER	NITROGEN	
						In feces and urine	In urine
	days		*grams*	*grams*	*grams*	*grams*	
221D							
886-IV	3	Average, all	6.810	854.5	260.3	73.5	
		Average, omitting collection of first 24 hours	5.026	621.3	194.9	57.1	
		Average, last two days' collections	3.642	459.8	143.6	50.7	
885-IV	3	Average, all	6.533	793.3	251.1	58.8	
		Average, omitting collection of first 24 hours	4.157	524.1	166.4	40.9	
		Average, last two days' collections	2.039	233.4	58.6	34.8	
221E							
885-III	6	Average, all	4.319		136.4	52.5	
		Average, omitting collection of first day	3.427		103.7	47.7	
		Average, omitting collection of first two days	3.203		103.4	43.5	
		Average, omitting collection of first three days	3.790		104.5	54.4	
		Average, omitting collection of first four days	3.508		52.6	48.7	
		Average, last two days' collections	3.360		59.7	42.7	
221F							
874-III	9	Average, all	4.318	490.1	119.4	51.2	
		Average, omitting collection of first day	3.875	382.9	91.1	47.0	
		Average, omitting collection of first two days	3.691	332.3	73.5	42.9	
		Average, omitting collection of first three days	3.673	294.5	56.6	42.5	
		Average, omitting collection of first four days	3.786	324.4	46.3	44.7	
		Average, omitting collection of first five days	3.983	321.5	43.1	48.6	40.7
		Average, omitting collection of first six days	4.350	332.7	44.7	51.9	44.9

887-III	9	Average, all	5.588	482.4	134.1	54.8	
		Average, omitting collection of first day	4.558	355.2	100.8	47.3	
		Average, omitting collection of first two days	4.535	329.0	93.1	44.4	
		Average, omitting collection of first three days	4.981	335.5	92.4	48.0	
		Average, omitting collection of first four days	4.929	293.0	79.8	42.2	
		Average, omitting collection of first five days	5.269	290.0	78.1	40.8	28.7
		Average, omitting collection of first six days	5.615	276.1	68.1	40.8	31.2

derived from feed residues remaining in the alimentary tract at the beginning of the fast. Because of the great irregularity of excretion of feces and urine, aside from other considerations, the data of table 3 do not show clearly the progress of the fast, and it is therefore difficult to determine how many days following the withholding of feed should be regarded as representing transition from feed to actual fasting, and whether or not the urinary nitrogen of the last four days of the nine-day fast may be regarded as representing exclusively katabolism of body protein. In order to reduce the effect of irregularity of excretion, and to facilitate the interpretation of the data, we have computed from the data of table 3 several averages of the daily excretions, first, basing the average on all collections during the fasting periods, and then omitting successively the collection of the first day, first two days, etc. These averages are given in table 4.

The data of table 4 should be studied in conjunction with the data of table 3 from which they were derived. In view of the fact that we have no available data for the urinary nitrogen of the three-day fasts and of the first few days of the longer fasting periods, it is impossible to state definitely when actual fasting, or the post-resorptive state, was reached. However, the great drop in excretion of total nitrogen between the first and third days in all experiments (table 3), and the practical uniformity of the average excretion of dry matter, crude fiber and total nitrogen, omitting successively the collection of the first two, three, four, five and six days of the nine-day fasting period (table 4), indicate very strongly that the excretion of the first two days after feeding cannot be regarded as representing fasting conditions, but that these conditions were reached soon thereafter, and that the urinary nitrogen of the last four days of the nine-day fasting periods may be safely regarded as not being affected to an important degree by the residual feed in the alimentary tract.

It will be observed (table 4) that the average daily excretion of nitrogen in feces and urine for the last three days of the nine-day fast, is greater, with cow 874, than any of the other averages.

This is evidently due to the extraordinarily heavy excretion during the last fourteen hours of the fast (table 3), which is included in the average, and to the smallness of the number of days upon which the average is based.

The average daily excretion of urinary nitrogen for the last four days, by cow 874, is 40.7 grams, and for the last three days is 44.9 grams. With cow 887 the average for the last four days is 28.7 grams, and the average for the last three days is 31.2 grams. These differences between the averages for the last four and the three last days of the nine-day fasting periods are also obviously due to the irregularity of the daily excretions; and on this account the average based on the larger number of days is considered more nearly to represent the protein katabolism of fasting.

In the periods of maintenance feeding which immediately preceded these fasting studies nitrogen equilibrium was approximated (see table 1) in the presence of slight gains of energy, with the ingestion of 97.4 grams of nitrogen by cow 874, of which 73.1 grams were apparently digested, and 89.0 grams of nitrogen by cow 887, of which 68.5 grams were apparently digested. The comparison of these values for digested nitrogen with the nitrogen excreted per day in the urine (40.7 and 28.7 grams) by these animals during fasting suggests that in the feeding periods they received a considerable surplus of protein above that required for maintenance, although this is not shown by the balances of nitrogen (+2.1 and −3.8 grams), from which we may infer that practically all the surplus protein was used by the animals for energy production, in which case, of course, it would be without effect on the nitrogen balance.

The live weights of cows 874 and 887 in these fasting experiments differed by almost 100 kgm. The average of the last four weighings (see table 2) is 397.1 kgm. for cow 874, and 298.4 kgm. for cow 887. On the basis of these averages and the figures for average daily excretion of urinary nitrogen, per head, during the last four days of the nine-day fasting periods, namely 40.7 grams for cow 874, and 28.7 grams for cow 887, the urinary nitrogen excretion of fasting, computed per 1000 pounds live

weight, per day, is 46.5 grams for cow 874, and 43.6 grams for cow 887. These nitrogen values, considered as representing protein katabolism of fasting, that is, katabolism of body protein, are equivalent (using the factor 6.0) to 279 grams, or 0.62 pounds, of protein for cow 874, and 261.6 grams, or 0.58 pounds, for cow 887. The average for the two cows is 270.3 grams, or 0.60 pound, of protein.

It is of significance to note that the protein katabolism of fasting of these animals is exactly the same as Armsby's (1) estimate of the maintenance requirement of digestible crude protein, namely, 0.6 pound per 1000 pounds live weight.

SUMMARY

Results are reported of the daily excretion of urine and feces, and their content of dry matter, crude fiber and nitrogen, from four dry, fasting cows, one fasting for a period of three days, one for periods of three and six days, and two others for a period of nine days.

The results indicate that the bulk of the residual feed which is contained in the intestinal tract at the beginning of a fast is eliminated during the first two or three days after feeding, but that, in the absence of treatment directed toward the freeing of the alimentary tract from excreta, as in these experiments, the elimination of the same is incomplete even after nine days of fasting.

The average daily nitrogen excreted in the urine during the last four days of the nine-day fasting periods, which is considered to represent, with fair accuracy, the protein katabolism of fasting, was 46.5 grams for one cow, and 43.6 grams for the other, per 1000 pounds live weight. These nitrogen values are equivalent to 0.62 pound, and 0.58 pound, of body protein, respectively, or 0.6 pound, as an average, per 1000 pounds live weight, which figure is identical with Armsby's published estimate (1) of the digestible crude protein maintenance requirement of cattle, and is 0.1 pound less than as in Morrison's standard (3) (0.7 pound), which may be considered as providing more liberally for reproduction and other exigencies of practice.

It should be borne in mind, however, that the above values for protein katabolized during fasting may not represent the minimum protein requirement during feeding, in which case an abundant supply of non-nitrogenous nutriment may reduce the katabolism of protein to an amount less than that prevailing during fast. These figures for protein katabolism of fasting, therefore, when used as measures of the protein maintenance requirement during feeding, must be considered as providing a certain margin of safety.

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SOME FACTORS AFFECTING THE GROWTH OF CERTAIN STRAINS OF P. ROQUEFORTI

I. BLUE MOLD*[1]

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INTRODUCTION

Previous work on the manufacture and ripening of Wensleydale cheese (3) has shown that in certain cases good mold growth was developed in the cheese. In the same experiments other cheese using similar milk under identical conditions the blue mold failed to develop. As all cheese had been inoculated, it is inconceivable that an absence of mold spores can be responsible for the lack of mold growth in the cases specified. But rather, that the causes of lack of mold growth might be looked for, in some inhibiting factor, or absence of suitable conditions for growth.

The lack of oxygen in the cheese, as shown by Thom and Currie (10), can hardly be considered the only factor as the mold in the best cheese usually develops first in the center (8).

In the previous work on the process of manufacture of Wensleydale cheese (3) it is shown that a starter was added to the milk and that acidity was developed in the making process. It is shown that this acidity is due to the organisms added in the starter and to the organisms in the raw milk.

The work of Hammer and others (4) (5) shows clearly that marked differences exist in starters as regards the associate organisms they contain and the acids that are produced. That the type of acid formed by these organisms might play an important part in providing a suitable medium for the growth of the

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[1] Thanks are tendered to the Department of Dairying, of the Iowa State College, Ames, Iowa, and to the Department of Dairying, of the University of British Columbia, Canada, for facilities granted and assistance given.

mold has suggested itself. Matheson (6) reporting on the manufacture of Roquefort cheese recommends a liberal use of starter but gives no details as to the type of starter to be employed. Benson states "the ordinary commercial starter of Bacterium lactis is, however, not the right thing," for Stilton or Wensleydale cheese (1). It is conceivable that the difference of opinion might well exist owing to different types of starter having been used.

Arising from the foregoing considerations, the work reported in this paper has been pursued.

OBJECT OF WORK

The object has been to determine the influence on different strains of P. roqueforti of acetic and citric respectively using such percentage of the same as possibly might be found in sour milk (4) (5) (9).

CULTURES USED

The cultures of P. roqueforti used were:

No. 1, P. roqueforti secured from Dairy Division, Washington (2).

No. 16, Isolated from Wensleydale cheese (2).

No. 32, Isolated from Wensleydale cheese inoculated with culture 16 (3).

No. 33, Isolated from Wensleydale cheese inoculated with culture 16 (3).

MEDIA

Milk. Sweet skim milk in which no bacterial change had taken place was used in every case. Test tubes of uniform diameter were selected, filled with exactly 10 cc. of milk, plugged and sterilized.

Milk + citric acid. A citric acid solution was made of such strength that it contained 0.0327 gram of citric acid ($C_6H_8O_7 + H_2O$) per cubic centimeter. This was added to test tubes plugged and sterilized. The milk and acid solution were well cooled and two lots of acid milk of high and low concentration were prepared by adding 1 cc. and 0.5 cc. respectively to each 10 cc. tube of milk, under sterile conditions. The concentrations of citric

acid were, therefore, 0.272 and 0.1423 per cent ($C_6H_8O_7$, H_2O), respectively.

Milk + acetic acid. An acetic acid solution was made up of such strength that it contained 0.01008 gram of acetic acid per cubic centimeter. Owing to the volatile nature of acetic acid, 1 cc. of glacial acetic acid, assumed to be sterile, was added to 100 cc. of sterile water. The milk and acid solutions were thoroughly cooled and two lots of acid milk of high and low concentrations were prepared by adding 1.5 and 0.5 cc. respectively, to each 10 cc. tube of milk under sterile conditions. The concentrations of acetic acid in the milk were 0.131 and 0.048 per cent (CH_3COOH), respectively.

Standard medium. Standard medium originating in part from Czapeks formula (10) was made up as follows:

Distilled water	2000 cc.
Magnesium sulphate	1 gram
Dipotassium phosphate	2 grams
Potassium chloride	1 gram
S. ferrous sulphate	0.02 gram
Peptone	20 grams
Lactose	50 grams
Agar	30 grams

Standard medium + citric acid. Two concentrations of standard medium and citric acid were prepared of such strength that either 1 or 0.5 cc. of the solution of citric acid (0.0327 gram per cubic centimeter) were added to each 10 cc. of the standard medium; the media were then tubed and sterilized. By this method concentrations of citric acid were obtained of 0.272 and 0.1423 per cent ($C_6H_8O_7$, H_2O), respectively.

Standard medium + acetic acid. The acetic acid solution was prepared as in the case of the milk and acetic acid previously referred to. To each 10 cc. test tube of the sterile standard medium either 1.5 or 0.5 cc. of this solution (0.01008 gram CH_3COOH per cubic centimeter) were added under sterile conditions. By this method concentrations of acetic acid were obtained of 0.131 and 0.048 per cent CH_3COOH, respectively.

METHODS

Inoculation. The test tubes of milk were inoculated from stock cultures grown on potato agar (11) using a platinum needle.

The plate cultures were first poured and allowed to cool on a flat surface. The inoculation was done from the cultures using a platinum needle, and every endeavor was made to develop but one colony and that in the middle of the plate.

Incubation. All cultures were grown in a room temperature incubator which averaged 21°C. and maintained a temperature between 22.5° and 20°C.

Measurement of growth in milk. The method used to determine the degree of growth in the milk, and modification of milk, was to hold the cultures ten days after inoculation and then determine the percentage of casein not digested. Standard Methods of Analysis were used (7) and the Kjeldahl determinations were made by the Gunning method.

Measurement of growth on solid media. The growth on the plates of solid media was recorded after the third day and then daily. This record included:

Margin, average width in millimeter
Size, average diameter of colony
Color of spores, when spores were formed
Color of reverse of colony

In measuring the rate of growth, it was found that the average diameter of the colony in millimeters was the most satisfactory way of expressing the rate of growth of the mold.

DIFFERENT STRAINS OF P. ROQUEFORTI GROWN IN MILK AND ACIDIFIED MILK

Four varieties of milk media, as previously described, were used in this experiment (see table 1). The high concentration of citric acid was not analyzed as considerable coagulation and precipitation of the casein took place when the acid was added. Quantitative determinations were made of the degree to which the cultures of different strains of P. roqueforti digested the casein of these milks.

The conclusions to be drawn from table 1 are:

1. The mold cultures of P. roqueforti 1 and 33 respectively (Roquefort origin) have a greater power to digest the casein than have cultures 16 and 32 (Wensleydale origin); which findings confirm previous work (2) (3).

2. There is a tendency for low concentrations of citric and acetic acids to effect the digestion of casein in milk by P. roqueforti:

TABLE 1

Different strains of P. roqueforti grown in milk and acidified milk cultures grown at room temperature in test tubes for ten days

CULTURES	MILK		MILK + 0.5 cc. ACETIC ACID OR 0.048 PER CENT ACETIC ACID		MILK + 1.5 cc. ACETIC ACID OR 0.131 PER CENT ACETIC ACID		MILK + 0.5 cc. CITRIC ACID OR 0.1423 PER CENT CITRIC ACID	
	Per cent casein	Per cent of casein digested*	Per cent casein	Per cent of casein digested*	Per cent casein	Per cent of casein digested*	Per cent casein	Per cent of casein digested*
Uninoculated control.....	3.10		3.04		3.08		3.03	
1	2.20	29.0	2.35	22.7	2.51	18.5	2.18	28.1
33	2.08	32.9	2.28	25.0	2.18	29.2	1.87	38.3
Average.....		30.9		23.8		23.8		33.2
16	2.79	10.0	2.96	2.6	2.83	8.1	2.68	11.6
32	2.87	7.4	2.91	4.3	2.82	8.4	2.67	11.9
Average.....		8.7		3.4		8.2		11.7

* This figure represents the percentage of the total casein that has been rendered soluble.

a. Acetic acid tends to reduce this digestion of casein particularly in weak concentrations.

b. Citric acid tends to increase this digestion of casein.

DIFFERENT STRAINS OF P. ROQUEFORTI GROWN ON THE STANDARD MEDIUM AND ACIDIFIED STANDARD MEDIA

In this experiment five modifications of media were used—the standard medium, a high and low concentration of the standard media and citric acid (figs. 1 and 2).

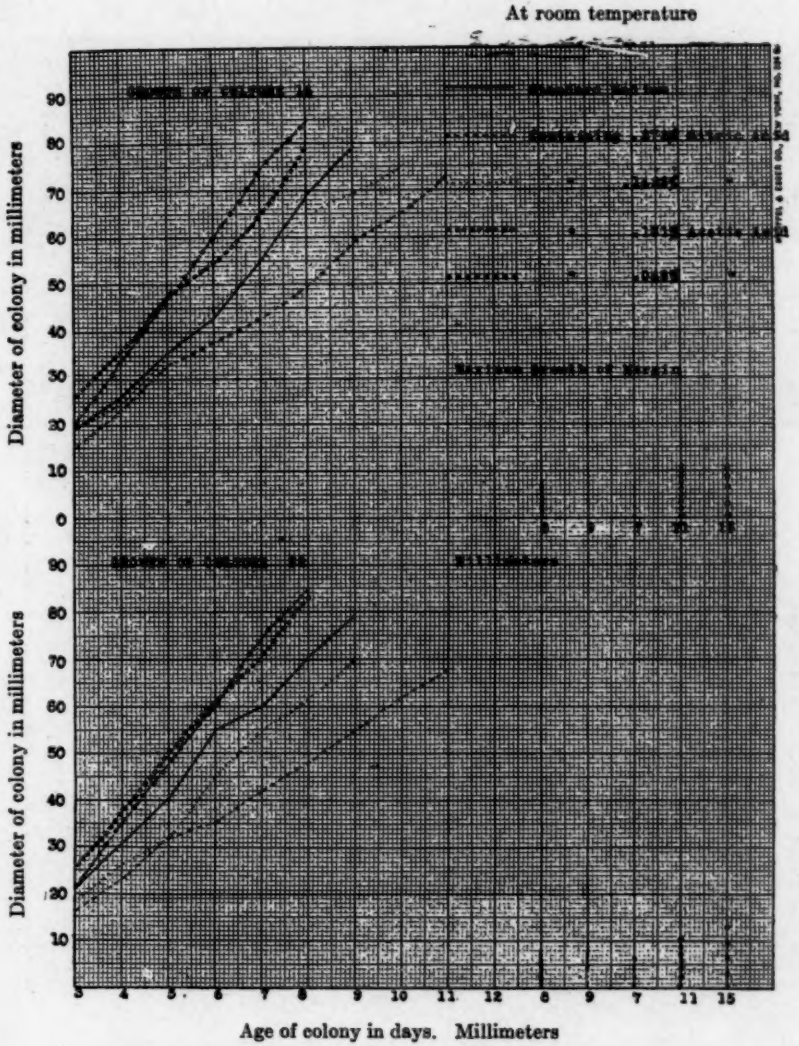
At room temperature
Diameter of colony in millimeters
Diameter of colony in millimeters
Age of colony in days. Millimeters

FIG. 1

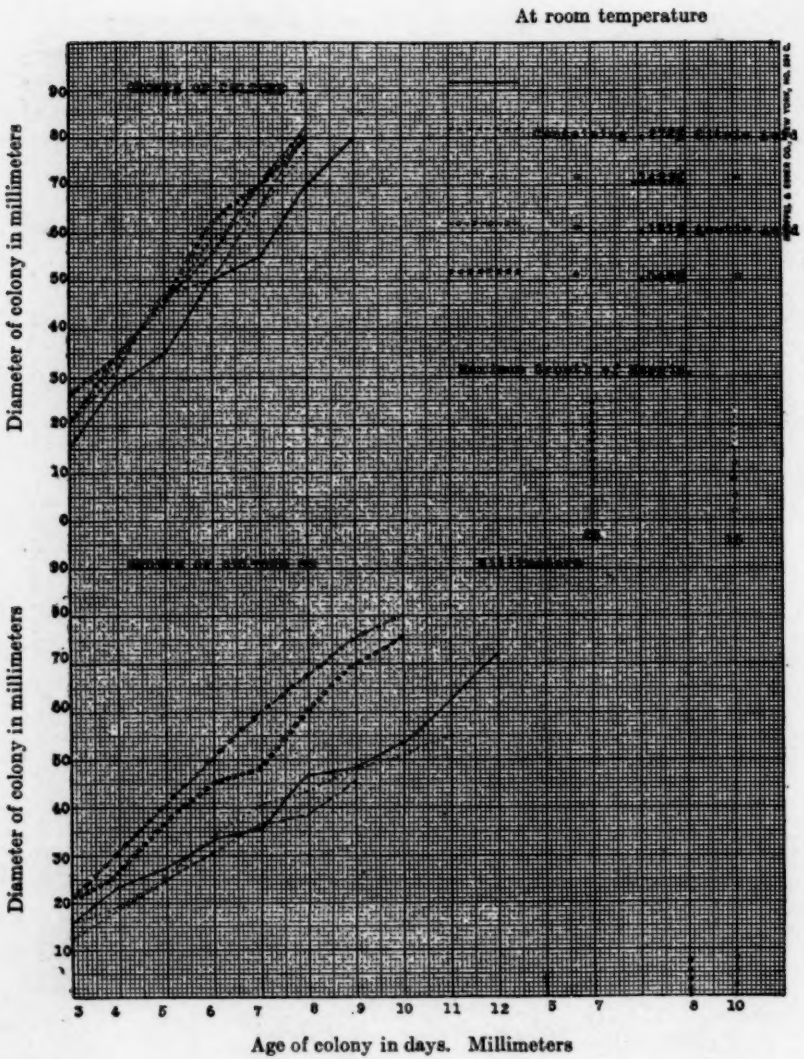
At room temperature
Diameter of colony in millimeters
Diameter of colony in millimeters
3 4 5 6 7 8 9 10 11 12 5 7 8 10
Age of colony in days. Millimeters

FIG. 2

All plates were inoculated in duplicate and the average diameter of the colony on the two plates was measured daily and expressed in millimeters. The rate of growth has been expressed graphically for each culture, figures 1 and 2. The conclusions to be drawn from figures 1 and 2, are:

1. Citric and acetic acids when in small quantities in the standard media have a marked effect on the rate of growth of the mold.

2. Cultures 16, 32, 33, grow much faster where acetic acid is supplied to the standard media and this growth increases with the higher concentration.

3. Cultures 16, 32, 33, grow much slower where citric acid is supplied to the standard media and this growth decreases with the higher concentration.

4. Culture 1 does not follow this rule. This strain increases in growth with the presence of either acid, but shows a slight preference for acetic acid.

5. The width of the margin is in conformity with the rate of growth; the wider the margin the faster the growth.

From the other data recorded, the following facts are of significance:

1. In the case of cultures 16, 32, 33, the reverse of the colony is almost white, in plates containing high citric acid concentration; this effect is noticed to a less extent with the low concentration. In the case of culture 1, this effect was not observed.

2. Cultures 16 and 32, produce fewer spores and a quite distinctive hairy growth when grown on the media containing acetic acid.

SUMMARY

Citric acid and acetic acid in amounts comparable with those found in starters (4) (5) (9) have an effect on the growth of different strains of P. roqueforti, both as effecting the digestion of casein and growth on the standard media described. Low concentrations of acetic acid tend to reduce the digestion of casein in milk by strains of P. roqueforti while citric acid tends to increase this digestion.

On the other hand in the standard media acetic acid increases the growth while citric acid tends to inhibit it.

This work would indicate that the type of starter used in the manufacture of blue veined cheese might have a significant bearing on the subsequent growth of the mold in the cheese. At this stage it is advisable to point out that before definite conclusions can be drawn more work will have to be done, both culturally and as applied to the manufacture of blue veined cheese.

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THE RÔLE OF THE ANTISCORBUTIC VITAMIN IN THE NUTRITION OF CALVES*

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It is definitely known that man, the guinea pig and the monkey require a certain amount of the substance which is termed vitamin C or the antiscorbutic vitamin; and that unless the required amount of this vitamin is supplied by the food a hemorrhagic disease known as scurvy develops. It is also known that the rat, when fed on rations which produce scurvy in man, or in the animals mentioned, fails to develop the disease. The experimental work of Parsons and co-workers (1) (2) (3) and of Lepkovsky and Nelson (4) gives considerable evidence that the rat is able to synthesize the antiscorbutic vitamin and store it in the liver. These investigators consider this an indication that this rodent requires vitamin C and that its body is able to produce the vitamin for use even though there is little or none present in the feed.

A review of the literature on the subject of vitamin C does not reveal any instance on record where an experimental study has been made of the requirement of the bovine for the antiscorbutic factor. The need for definite knowledge regarding the role of the antiscorbutic vitamin in the nutrition of dairy cattle has been felt for some time both by veterinarians and by men interested in solving various problems in the field of cattle nutrition. Two outbreaks of a scurvy-like disease of cattle have

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been reported, one from England, the other Australia, apparently caused by faulty nutrition. A striking similarity is noticeable between the characteristics of the disease as reported for these cattle and the well known symptoms of scurvy as found in guinea pigs which have been fed rations deficient in the antiscorbutic vitamin.

Place (5) of Australia says,

> Look for a moment at a case of scurvy with its anemia and cachexia, its local hemorrhages and hemorrhagic inflammation, the spots upon the ribs, their dislocation from cartilages with perhaps neuritis and anesthesia of the limbs, and compare it with a coasty heifer with her bloodless eyes and bottled jaw, her gaspy breath, due to her ribs failing to distend, her tottering walk and swollen fetlocks, and finally her feeble, helpless efforts to control her limbs and raise her wasted carcass.

Place further states that "one of the symptoms of this form of disease in cattle (dental trouble) is a blue hyperemia of the gums and in some instances ulceration."

The occurrence of such a disease in England was noted by Little (6) who reports finding heifers, which had been fed on a ration that would undoubtedly produce scurvy in guinea pigs, showing many of the symptoms commonly noted in animals known to have scurvy. When first noticed some of these animals were dead or dying. On investigation Little diagnosed the cases as scurvy and was actually able to prevent further deaths by feeding either green grass, kohl rabi or swedes. Whether these outbreaks were due to a deficiency or absence of the antiscorbutic vitamin, or whether they were due to some other nutritional cause has been the point for considerable debate. The authors believe that the results of the experiment herein reported will throw light upon this particular question.

EXPERIMENTAL

The first consideration in an experiment of this nature was to secure a ration which while deficient or lacking in vitamin C, would furnish adequate quantities of all the other nutritional factors necessary for life and growth. Since the requirement

of the bovine for many of these factors was at the time unknown it was necessary to base all considerations on the nutritional requirements of small laboratory animals.

The work reported in this paper was divided into two experiments. The first experiment gave significant results, but it was clear that the procedure could be improved considerably, and for this reason certain changes were made in the experimental methods followed in the second experiment.

Experiment 1

Ration. Specially treated alfalfa hay was the roughage fed during the first five months of experimental feeding. Treatment of this alfalfa consisted of autoclaving it for thirty minutes at a pressure of 15 pounds. Oat straw was substituted for the treated alfalfa hay during the fifth month because the demands of the calves for increased amounts of roughage became so great that it was difficult to autoclave as much alfalfa as the calves required.

Milk was fed to all the calves until they reached the age of six months. After considerable experimentation a definite method for treating the milk was adopted. The milk was heated to a temperature of 180°F. and held at that point for one hour. Throughout the time of holding oxygen from a storage drum was allowed to bubble through the milk at the rate of about 1 cubic foot per minute.

A grain mixture was fed consisting of 3 parts corn, 3 parts oats and 1 part old process linseed oil meal. To this mixture was added 5 per cent butterfat as a source of vitamin A and the antirachitic factor. One per cent of salt was also added. When the roughage was changed from alfalfa to timothy hay 183 grams of calcium carbonate were added to every 100 pounds of grain.

Animals. Four grade calves of uniform weight and appearance were used in this experiment. Two of these calves, E-3 and E-4, were used as experimental animals and received the ration deficient in the antiscorbutic factor. The other two, E-1 and E-2 were used as controls. The controls received the

same ration as the experimental calves with the exception that vitamin C was supplied. Lemon juice was first used as a source of this vitamin but the labor and expense involved soon caused

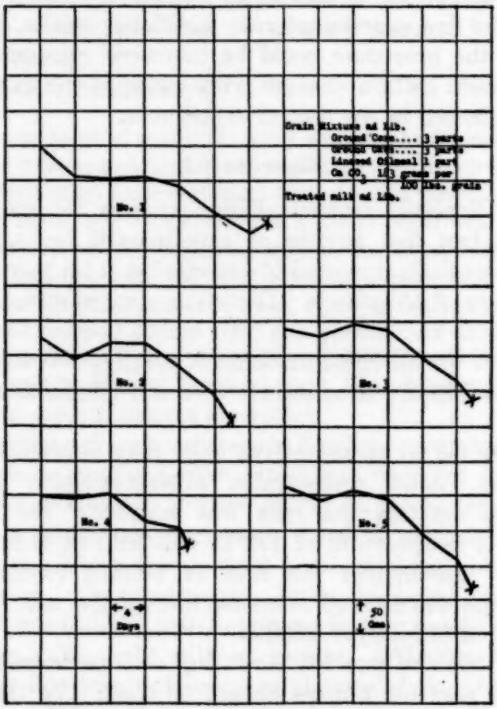

FIG. 1. WEIGHT CURVES OF GUINEA PIGS USED IN A FEEDING TRIAL TO DETERMINE THE SCORBUTIC POTENCY OF MILK WHICH HAS BEEN HELD FOR ONE HOUR AT A TEMPERATURE OF 180° F. WHILE OXYGEN BUBBLED THROUGH IT AT THE RATE OF ABOUT 1 CUBIC FOOT PER MINUTE

Horizontal squares represent four days, while vertical squares represent 50 grams.

the substitution of tomato juice and tomatoes were then used throughout the experiment.

During the early part of the experiment all of the feeds used were tested for their content of the antiscorbutic factor by feeding

trials with guinea pigs. All of the feed-stuffs used were shown to be deficient in vitamin C as they caused a rapid decline in the weight of the guinea pigs and finally death. Autopsy invariably showed very noticeable signs of scurvy. The data on one of the experiments, the results of which are typical of all the others, are presented in figure 1.

Effect of deficiency of vitamin C on growth and appearance of calves. Experimental feeding of the calves used in this trial

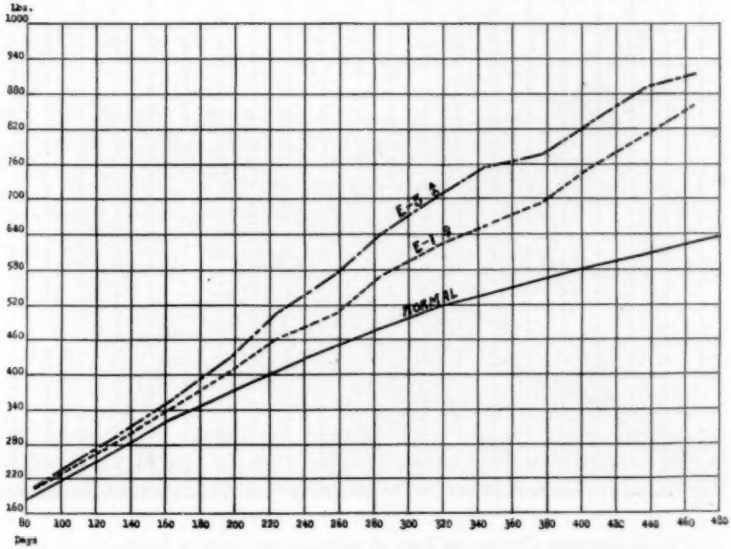

FIG. 2. GROWTH CURVES OF TWO OF THE CALVES USED IN EXPERIMENT 1

E-3 received a vitamin C deficient ration while E-1 received the same ration supplemented by tomato juice as a source of vitamin C.

was begun in November, 1922, when the calves were all approximately one hundred days old. During the following winter careful and numerous observations were made with the expectation that early signs of scurvy might be detected by noting the appearance and action of the calves. About January 26 signs of stiffness were noticed in the control calf E-2 and in the experimental calf E-3. Later in the winter all four of them showed

abnormal stiffness of the joints. This stiffness cannot be attributed to a deficiency of the antiscorbutic vitamin, however, for two reasons: First, the stiffness occurred in the control calves receiving the tomato juice as noticeably as it occurred in the experimental calves; and second, the stiffness disappeared when cod liver oil was substituted for butterfat in the ration, and never occurred during the second trial when the ration was

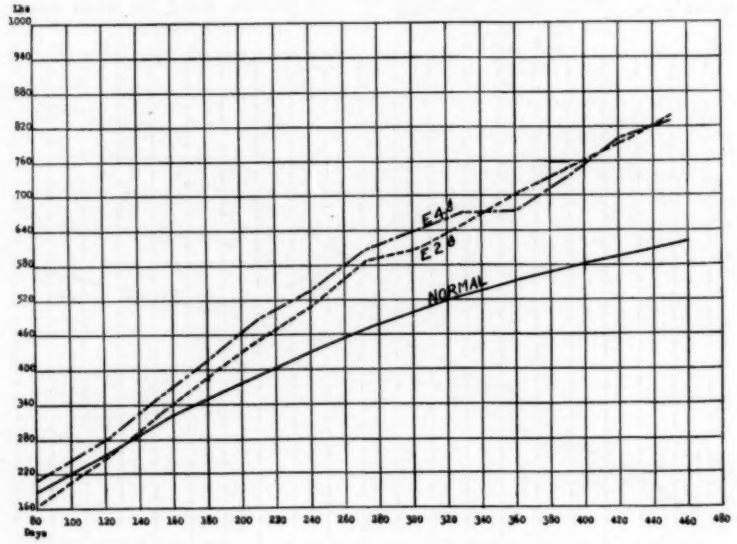

FIG. 3. GROWTH CURVES OF TWO OF THE CALVES USED IN EXPERIMENT 1

E-4 received a vitamin C deficient ration while E-2 received the same ration supplemented by tomato juice as a source of vitamin C.

supplemented by cod liver oil and calcium carbonate. The growth of the experimental calves was fully equal to that of the controls.

Figures 2 and 3 give a comparison of the growth curves of the experimental calves and the controls with the normal growth curve. Figures 4 and 5 show two of the calves as they appeared at the close of the experimental feeding.

Autopsies were made on both of the experimental calves and

on one of the controls at the close of the experiment. These autopsies failed to show the lesions characteristic of scurvy. Following are the autopsy statements taken:

E-2 (control). Gums normal; teeth solidly imbedded in jaw; ankles and hocks normal. An abnormal amount of sinovial fluid and grease was found between the skin and flesh and between bone joints. The lymph glands and intestines were normal, no hemorrhagic areas being found. Small, nearly indistinguishable hemorrhagic spots were

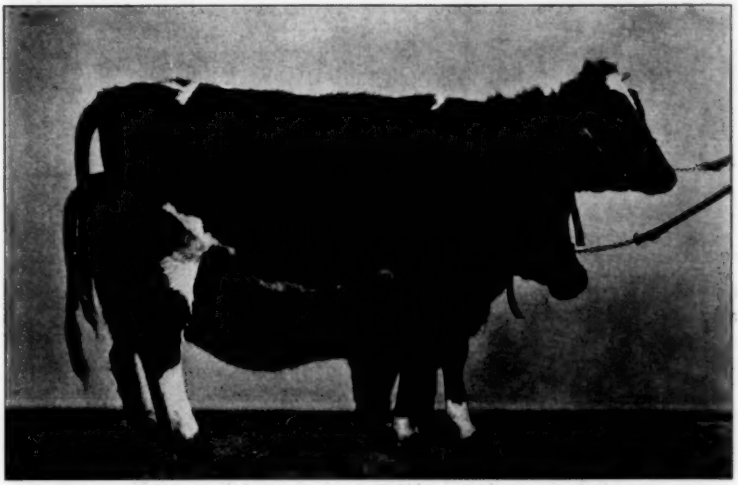

FIG. 4. CALF E-1 AT THE AGE OF 458 DAYS AFTER 364 DAYS ON EXPERIMENT

This animal received a vitamin C deficient ration supplemented by tomato juice. As might be expected she grew normally in every respect.

noticed at the costochondral junctions. The general condition of the carcass was pronounced normal both by the attending veterinarian and by the instructor in meats in the Agricultural College.

E-3 (experimental). Gums normal; teeth solidly imbedded in jaw; knee joints larger than normal but not hemorrhagic; hock joints had hemorrhagic spots 2 inches in diameter on each side. An abnormal amount of sinovial fluid was found in the joints. Intestines and lymph glands were normal and showed no hemorrhagic areas. The costochondral junctions were hemorrhagic and two of them were slightly

swollen. The carcass was pronounced normal except for the hemorrhagic areas noted above.

E-4 (experimental). Gums normal; teeth solidly imbedded in jaw; ankles normal; slightly distinguishable hemorrhagic areas on hock joints. A large abscess was found on the liver. The lymph glands of the intestines were hemorrhagic and slight hemorrhagic areas were noted on the costochondral junctions but no swellings could be found.

FIG. 5. CALF E-4 AT THE AGE OF 445 DAYS AFTER 365 DAYS OF EXPERIMENTAL FEEDING

This animal grew normally on a ration extremely low in its vitamin C content. Guinea pigs on the same ration die of scurvy in less than thirty days.

At the close of the experiment the control calf, E-1, was pregnant and was changed to the vitamin C deficient ration which she received for the three following months until she dropped her calf. This was done in order to secure a calf for a second trial that would have its body reserve of the antiscorbutic factor as low as possible. E-1 was slaughtered soon after calving, and some rather surprising abnormalities were found when her carcass was examined. All her costochondral junctions were

so greatly enlarged that they were noticeable as soon as the chest cavity was opened. Suspecting that these enlargements were characteristic of rickets rather than of scurvy several of the enlarged junctions were examined histologically by Dr. Kernkamp and through his courtesy the report which follows is available.

Histologically the section shows hyperplasia of osteoid tissue in certain areas. There is a proliferation of dense white fibers and also there are irregular masses of cartilage tissue with cartilagenous cells arranged in little groups or nests surrounded by a hyaline matrix. Marrow spaces were filled with white fibers, marrow cells and some blood vessels. However, the zone of calcification could be seen and was regular, but the band of proliferative cartilage was irregular.

Dr. Kernkamp believed the bone showed signs of rickets but hesitated to definitely pronounce it as a distinct case of rickets.

Experiment 2

The majority of the evidence accumulated as a result of the first experiment indicated that calves either have no vitamin C requirement or that the amount needed is so low that it cannot be measured by feeding trials with guinea pigs. However, the presence of a few of the scurvy-like lesions in the bodies of the experimental animals at the end of the trial as previously noted left some possibility of doubt as to the truth of such a conclusion. Consequently a second trial was begun in which it was the aim of the investigators to create more severe conditions relative to the deficiency of vitamin C, as well as to protect more efficiently against rickets by alterations in the ration.

In creating more severe conditions in this experiment calves less than two weeks old were placed immediately under conditions which would minimize the possible storage of the antiscorbutic factor. One of the calves, E-39, was dropped by E-1, which as previously mentioned, had for three months previous received a ration very deficient in vitamin C. By this means it was expected that the possibility of a reserve of that factor

would be considerably lowered. Three other calves were obtained from a grade cow market near the college.

The ration used in this trial varied in two particulars from that used in the previous one. A mixture of timothy and wild hay was used in this case in place of the oat straw. No butterfat was fed in this trial but a drench of cod liver oil was used as a source of vitamin A and the antirachitic factor. The grain mixture was the same as previously used.

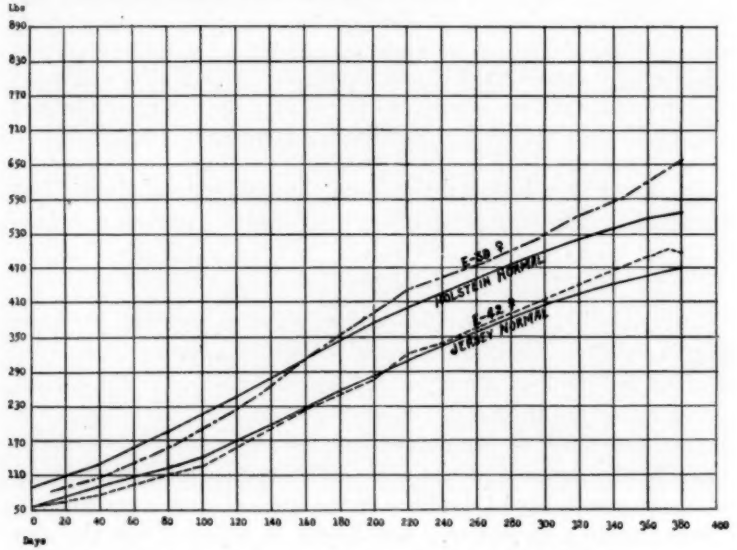

FIG. 6. GROWTH CURVES OF THE CALVES USED IN EXPERIMENT 2

E-39 received a vitamin C deficient ration while E-42 received the same ration supplemented by tomato juice.

The timothy and wild hay was bought in a quantity sufficient to last throughout the entire year. A representative sample of this hay was taken and fed *ad libitum* to guinea pigs along with the grain ration. All of the guinea pigs died of scurvy within three weeks. The other portions of the ration had already been tested in the previous trial and were known to be deficient in the antiscorbutic vitamin.

As in the previous trial the experimental feeding was carried on over a period of one year. At no time during this trial was stiffness noted in any of the calves. A glance at the growth curves (figs. 6 and 7) shows that all calves made normal growth and again the growth of the calves on the deficient ration was slightly better than that of the controls. Figures 8 and 9 show two of the calves as they appeared at the end of the experimental feeding.

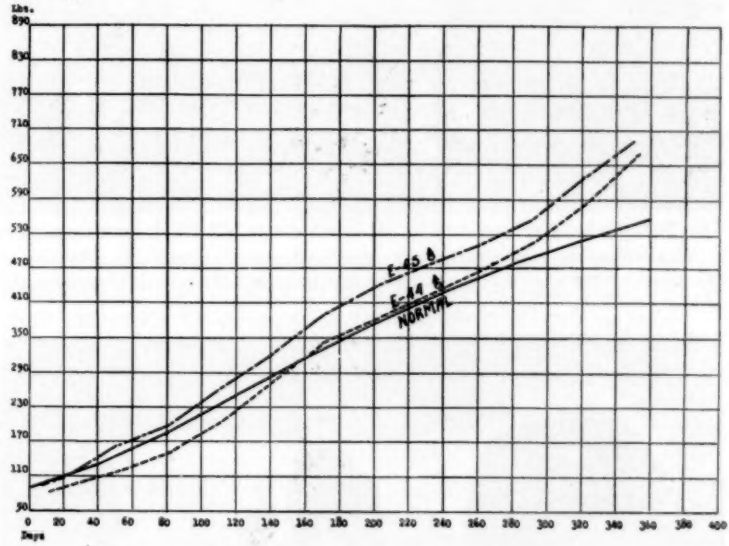

FIG. 7. GROWTH CURVES OF TWO OF THE CALVES USED IN EXPERIMENT 2

E-45 received a ration deficient in vitamin C while E-44 received the same ration supplemented by tomato juice as a source of vitamin C.

E-39 (experimental) is now pregnant and will not be slaughtered for autopsy. E-42 (control) was not slaughtered for autopsy. E-44 (control) and E-45 (experimental) were slaughtered, however, and the following autopsy findings were reported:

E-44 (control), Perfectly normal throughout except for excessive amount of oily fluid at joints. Ribs, teeth, gums, and internal organs were all normal.

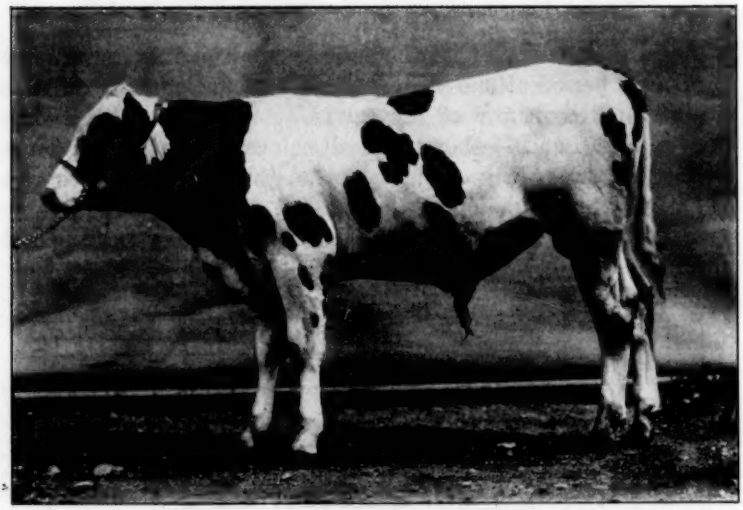

FIG. 8. CALF E-44 AT THE AGE OF 367 DAYS AFTER 365 DAYS ON EXPERIMENT

This animal received a ration deficient in vitamin C supplemented by tomato juice as a source of this vitamin. As might be expected this calf grew normally in every respect.

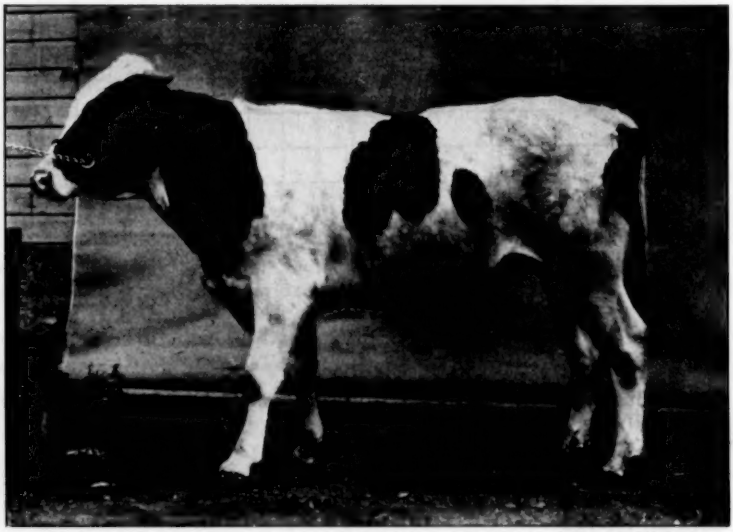

FIG. 9. CALF E-45 AT THE AGE OF 366 DAYS AFTER 350 DAYS ON EXPERIMENT

The animal grew normally on a ration extremely deficient in vitamin C. Guinea pigs on the same ration die of scurvy in less than thirty days.

E-45 (experimental). Perfectly normal except for oiliness at joints. The spleen was slightly hemorrhagic but all other organs, teeth, joints, and costochondral junctions were free from hemorrhagic areas and swelling. The calf did not have scurvy.

These results indicate that the stiffness noticed in the calves in trial 1 and the hemorrhagic areas and swellings found on autopsy may be attributed to a deficiency of minerals or to a deficiency of the antirachitic factor rather than to a deficiency of the antiscorbutic vitamin.

A study of the vitamin C content of the livers of these calves is now under way with a view of offering an answer to the question, does the bovine synthesize vitamin C or does it have absolutely no requirement for this factor? These results will be reported at a later date.

CONCLUSION

Calves do not require vitamin C in quantities that can be measured by the present method of testing food materials for their antiscorbutic potency by feeding them to guinea pigs.

Under practical conditions, even where very poor feeding practices are followed, there is little if any reason to believe the well-being of the calf will be affected by a shortage of vitamin C.

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HUMIDITY EQUILIBRIA OF MILK POWDERS*

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The absorption of atmospheric moisture by milk powders is a matter of no little consequence in its effect upon the keeping qualities of the product during storage. The preservation of its initial collodial structure and the prevention of the manifestation of the characteristic stale taste and odor and darkening of the color is to a large extent dependent upon the degree of success which can be attained in preventing the absorption of moisture from the air. Supplee and Bellis (1) have shown that a progressive development in the insolubility of milk powder casein is brought about by a moisture content and time relationship. Fouassier (2) has also shown the same phenomenon to be the result of a moisture and temperature relationship. Holm and Greenbank (3) have submitted data indicating that moisture content is involved in the development of tallowyness in dry milk containing fat, as well as in the development of a characteristic stale condition. These investigators state that a low moisture content is particularly favorable for the development of the tallowy condition, whereas a high moisture content causes a characteristic stale taste and odor defect described as fishy. These observations have been confirmed by the author (4) although the stale non-tallowy condition has in no instance been recognized as fishy.

The general agreement, even from limited data, as to the importance of moisture content of dry milk as a factor affecting its keeping properties during storage, warrants definite information showing the degree to which moisture may be absorbed under natural conditions. Such data have been obtained and are reported herein as representing substantially the humidity equilibria at various vapor pressures. The data are not presented as ab-

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solute humidity equilibria values because it appeared that certain samples would not reach stability for several months and possibly not until after several years. Therefore, in view of the normal periods during which milk powder is held, practical considerations were taken into account. In no case were records kept for longer than six months and in numerous instances where equilibrium had apparently been reached the final record was obtained after a much shorter period. The final data for those samples which had not reached constant weight were recorded only after two successive weighings two weeks apart showed a fluctuation of 0.05 per cent or less.

The methods described by Wilson (5) and Wilson and Fuwa (6) were used, but since information regarding the time required to reach equilibrium was desired, the aspiration method described by these writers was used only as a check method for a few samples. Since close agreement with the longer holding method was obtained, the results are not duplicated herein. Varying percentages of sulphuric acid solutions were used to obtain a range of vapor pressures corresponding to relative humidities from 10 to 80 per cent at 25°C. Approximately two grams of milk powder were placed in small vials and held over the different acid mixtures in tightly sealed Mason jars. Powders prepared by six different methods of manufacture, as well as powders containing different amounts of fat, were used for the determinations. All samples, when placed at the various humidites contained less than 2.5 per cent moisture and were representative of fresh normal stock unless otherwise noted. Weighings were made at short intervals during the first four weeks and at two week intervals thereafter. After hydration at the different humidities had been completed, or practically so, all samples at humidities lower than 80 per cent were placed in an atmosphere corresponding to this vapor pressure and allowed to reach equilibrium which in no case required more than three weeks. The samples were then returned to the respective humidities at which they had been previously hydrated. The purpose of this procedure was to determine whether the curve of dehydration corresponded to the hydration curve. As will be shown hereinafter marked differences were found.

TABLE 1

*Humidity equilibria of skimmed milk powders**

HUMIDITY	SAMPLE 1		SAMPLE 2		SAMPLE 3		SAMPLE 4		SAMPLE 5		SAMPLE 6		AVERAGE ALL SAMPLES	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
10	1.24	3.77	1.38	2.56	1.27	2.75	1.15	2.65	1.11	2.58	0.83	3.01	1.14	2.91
20	2.56	5.23	2.70	4.01	2.63	4.15	2.39	4.00	2.31	3.92	1.79	4.46	2.35	4.32
30	4.07	6.31	4.21	5.14	3.98	5.18	3.79	4.93	3.56	4.97	3.05	5.51	3.74	5.37
40	6.09	7.18	6.26	6.09	5.63	6.09	5.62	5.70	5.08	5.82	5.00	6.39	5.61	6.23
50	6.53	8.06	5.35	7.08	5.00	7.09	5.26	6.58	5.69	6.73	5.80	7.30	5.72	7.15
60	8.71	9.20	7.96	8.29	6.99	8.25	7.07	7.62	7.38	7.80	7.69	8.38	7.76	8.26
70	11.10	10.73	10.80	9.90	9.34	9.80	9.76	9.05	9.49	9.25	9.88	9.79	10.21	9.74
80	14.49	14.49	14.97	14.97	13.29	13.29	13.31	13.31	13.01	13.01	13.18	13.18	13.79	13.79

* Column 1 gives the hydration figures and column 2 the dehydration figures.

Table 1 shows the moisture content of six different brands of skimmed milk powder, each representing a different method of manufacture. Sample 1 represents a product made by the Just double cylinder process in which the milk is not pre-condensed. Sample 2 represents the product from a single roller drum process in which low drying temperatures are used and in which the milk

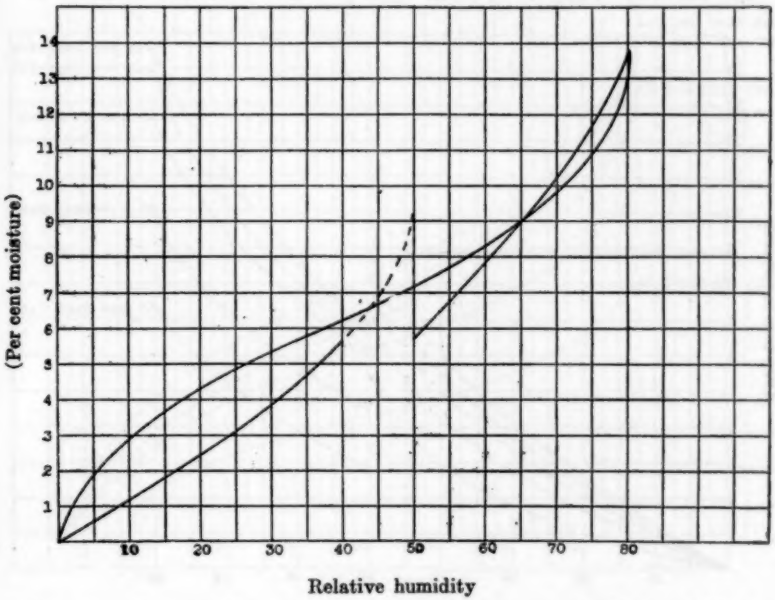

CHART 1. MOISTURE-HUMIDITY EQUILIBRIUM CURVES FOR SIX SKIMMED MILK POWDERS (TABLE 1)

The broken curve is hydration and the smooth curve is dehydration. The dotted section indicates the area of greatest instability.

is previously condensed. Sample 3 represents a spray process product in the manufacture of which unusually high initial temperatures are used. The milk is not pre-condensed. Sample 4 represents a product from a European centrifugal spray method in which the milk is precondensed. Sample 5 represents the product from a spray method extensively used in this country

and for which the milk is previously condensed. Sample No. 6 represents the product from a still different type of spray process employed in this country but for which the milk is not precondensed. The results given in table 1 are the averages obtained from triplicate samples.

Chart 1 is constructed from the average results obtained from the different samples of skim milk powders recorded in table 1.

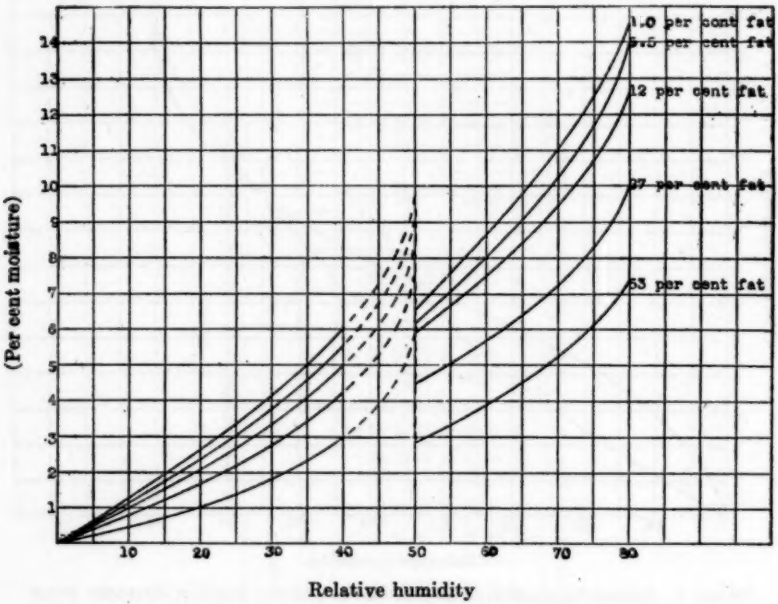

CHART 2. MOISTURE-HUMIDITY HYDRATION EQUILIBRIUM CURVES FOR JUST PROCESS MILK POWDERS WITH VARIABLE FAT CONTENTS (TABLE 2)
The dotted sections indicate the area of greatest instability

Table 2 shows the average results obtained from duplicate samples of Just Process powder containing variable amounts of fat. Charts 2 and 3 are constructed from the data in table 2, chart 2 showing hydration curves and chart 3 showing dehydration curves for the same powders. All results are reported on the basis of dry weight of the powder.

The results obtained show that the vapor pressure equilibria of milk powders involves certain features of peculiar interest. The characteristic type of the hydration curve and especially the break in this curve at approximately the same level for all powders of the same protein content, irrespective of the method of manufacture, but at different levels for powders with different

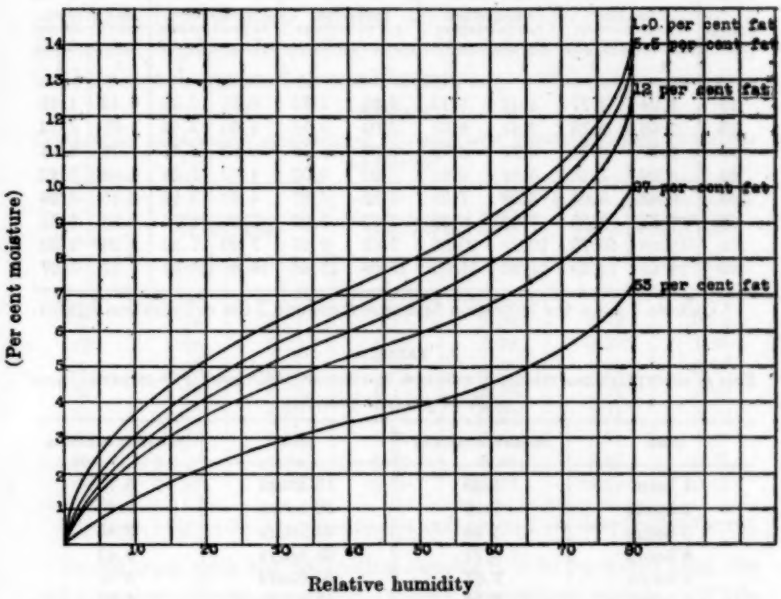

CHART 3. MOISTURE-HUMIDITY DEHYDRATION EQUILIBRIUM CURVES FOR JUST PROCESS MILK POWDERS WITH VARIABLE FAT CONTENT (TABLE 2)

protein contents, appears to involve the application of a fundamental principle governing moisture absorption by certain colloidal materials. (Chart 1 shows only the compositve curve for all skimmed milk powders, but if each powder had been charted separately the same phenomena would be revealed in each instance.) Special significance lies in the interpretation of the practical aspects of the results in that the maximum moisture content at 50 per cent humidity was found by actual measurement

to have been reached within a few hours. The rate of decrease, however, after the maximum had been reached and until constant weight was obtained, was very slow as illustrated by the fact that in practically all instances decreasing weights were recorded

TABLE 2

*Humidity equilibria of Just Process milk powders with variable fat content**

HUMIDITY	1 PER CENT FAT IN POWDER		5.5 PER CENT FAT IN POWDER		12 PER CENT FAT IN POWDER		27 PER CENT FAT IN POWDER		53 PER CENT FAT IN POWDER	
	1	2	1	2	1	2	1	2	1	2
10	1.24	3.77	1.12	3.13	0.91	2.75	0.77	2.33	0.42	1.31
20	2.56	5.23	2.41	4.61	2.00	4.14	1.69	3.59	1.01	2.22
30	4.07	6.31	3.75	5.70	3.31	5.18	2.83	4.51	1.79	2.94
40	6.09	7.18	5.67	6.61	4.98	6.02	4.32	5.25	3.04	3.42
50	6.53	8.06	6.20	7.58	5.88	6.87	4.48	5.90	2.85	3.96
60	8.71	9.20	7.92	8.69	7.50	7.90	5.61	6.72	3.88	4.51
70	11.10	10.73	10.28	10.20	9.47	9.29	7.20	7.92	5.23	5.42
80	14.49	14.49	14.00	14.00	12.68	12.68	10.01	10.01	7.37	7.37

* Column 1 gives the hydration figures and column 2 the dehydration figures.

TABLE 3

Rate of absorption and release of moisture by skimmed milk powder in an atmosphere with 50 per cent humidity

TIME	PER CENT MOISTURE	TIME	PER CENT MOISTURE
1 hour	4.26	18 hours	8.76
2 hours	5.19	30 hours	9.40
3 hours	5.98	33 hours	9.45
4 hours	6.71	38 hours	9.42
5 hours	7.07	53 hours	9.21
6 hours	7.36	65 hours	8.91
8 hours	8.02	9 days	7.88
10 hours	8.19	19 days	6.61
12 hours	8.35	28 days	6.51
14 hours	8.58	42 days	6.41
16 hours	8.68	56 days	6.38

at this humidity for a period of two to three months. An illustration of the rate of moisture absorption and subsequent release at 50 per cent humidity for one of the skimmed milk powders is shown in table 3. It is to be noted that absorption was very rapid during the first few hours and that the maximum was at-

tained after thirty-three hours. Thereafter there was a gradual decrease extending over a period of eight weeks before constant weight was reached. Rapid absorption in excess of the final equilibrium capacity was also noted at humidities of 60 and 70 per cent. The range, however, between the maximum and the point at which equilibrium was finally established, was not as great as at 50 per cent. The records from powder held at 40 per cent humidity or lower showed continuous absorption, or only slight dehydration depending upon the initial moisture content, to the point designated as equilibrium.

TABLE 4

*Comparison of humidity equilibria of skimmed milk powder subjected to various treatments**

HUMIDITY	FRESH SAMPLE NO TREATMENT		SAMPLE HEATED TO 100°C. IN VACUO FOR ONE HOUR		SAMPLE ALLOWED TO ABSORB 10 PER CENT MOISTURE AND THEN DRIED OVER P_2O_5 AT 50°C.	
	1	2	1	2	1	2
10	1.24	3.77	0.75	2.50	0.45	0.78
20	2.56	5.23	1.57	3.70	0.92	1.49
30	4.07	6.31	2.71	4.57	1.58	2.16
40	6.09	7.18	4.18	5.20	2.41	2.89
50	6.53	8.06	4.67	6.02	3.71	3.80
60	8.71	9.20	6.70	7.51	4.28	4.59
70	11.10	10.73	9.30	9.80	5.27	6.38
80	14.49	14.49	13.79	13.79	10.99	10.99

* Column 1 shows the hydration figures and column 2 the dehydration figures.

In contrast with the hydration results it is to be noted that the dehydration curves represent typical absorption curves. While various possibilities might be suggested as causing these differences, as well as in explanation of the characteristic hydration curves, it is believed that the most tenable explanation involves application of the general laws of capillarity as applied to colloidal matter. In this connection it is to be noted, however, that nearly three weeks were required for saturation at 80 per cent humidity before the samples were again returned to the lower humidities for dehydration. Since it has been previously shown (1) that high moisture and time are factors which bring about marked changes in the properties of milk powder casein, it is

probable that these samples at the beginning of dehydration possessed properties of an entirely different character than before hydration. The phenomenon of hysteresis may therefore be involved. Although the question of insufficient time for establishing complete equilibrium is not entirely excluded, this factor is considered to be irrelevant for all practical considerations. The

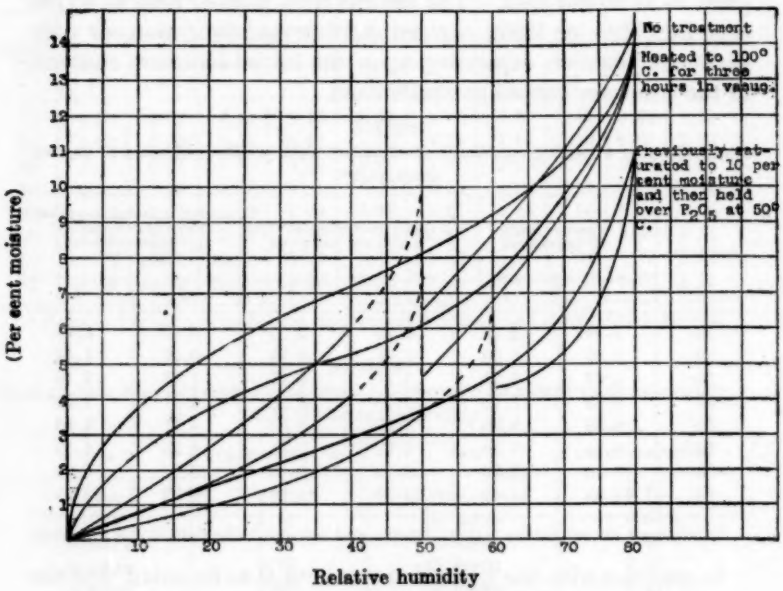

CHART 4. MOISTURE-HUMIDITY EQUILIBRIUM CURVES FOR JUST PROCESS SKIMMED MILK POWDER SUBJECTED TO PREVIOUS HEAT TREATMENT AND MOISTURE SATURATION (TABLE 4)

The broken curves are hydration and the smooth curves are dehydration. The dotted sections indicate the areas of greatest instability.

possiblity of hydration of anhydrous lactose has been considered, and while it is known that such a change does take place in milk powder of high moisture content after prolonged storage, the information obtained in connection with this work indicated that the anhydrous form was not completely converted to the stable monohydrate.

It is well known that the absorptive properties of collodial matter may be materially altered by the conditions to which it is subjected. It is therefore deemed desirable to include data showing the degree to which the absorptive properties of milk powder may be affected by certain treatments. A sample of skim milk powder made by the Just process, and for which the absorption data has already been recorded, was divided into two parts and treated as follows: One part was dried in vacuo at 100°C. for one hour and then subdivided and held at various humidities as heretofore described. The second part was placed in a saturated atmosphere until it had absorbed 10.53 per cent moisture. It was then immediately placed over phosphorus pentoxide and dried at 50°C. When completely dried it was subdivided and placed at the different humidities already indicated. The hydration and dehydration results are shown in table 4 and chart 4. In comparing these records with those obtained from the normal skimmed milk powder of the same composition it is to be noted that the same general type of curves were obtained. In both instances, however, lower equilibrium levels were found. Furthermore, the results obtained from the saturated sample subsequently dried at a low temperature were lower than those obtained from the sample heated to a high temperature but which had not previously contained a high moisture content.

These results from the artificially treated milk powder are probably of little value for practical interpretation but nevertheless they serve to illustrate the effect of heat treatment and previous moisture absorption on the subsequent ability of such products to retain moisture at different vapor pressures. It would be of interest to study the effects of analogous relationships as they apply to milk powders subjected to different heat treatments during the process of manufacture.

While it has been impossible to include data showing the absorption of moisture at humidities above 80 per cent due to difficulties from mold formation, records were obtained for a limited period wherein the absorptive capacity of skimmed milk powder in a saturated atmosphere is shown in a striking manner.

The particular sample in question absorbed 6.25 per cent of its dry weight during the first half hour of exposure. At the end of four hours the moisture content was 15.49 per cent; after twenty-five hours it was 27.25 per cent; and after one hundred hours a moisture content of 51.11 per cent was recorded.

It is not to be inferred that the data recorded in this paper can be applied directly to any particular lot of milk powder held at the given humidities. These results represent maximum absorptive capacity. As a rule lower moisture contents of commercial samples will be found, because of the variable degrees of protection which the container affords and because of slow diffusion through the mass. It is not uncommon, however, to find a moisture content 4 to 5 per cent higher in the outside areas of a barrel of milk powder than is found at the center.

SUMMARY

1. Data are given showing the moisture content of various milk powders at equilibrium in vapor pressures corresponding to humidities from 10 to 80 per cent at 25°C.

2. It is shown that the absorption of moisture by milk powder irrespective of the method of manufacture, apparently proceeds according to certain fundamental laws governing absorption by collodial matter.

3. The data show that at humidities above 50 per cent the initial moisture absorption is very rapid, and at humidities between 50 and 70 per cent this initial absorption is not retained by the powder. When the maximum is reached a dehydration process begins and extends over a period of months before equilibrium is established at a lower level.

4. The dehydration results obtained after milk powder had been subjected to a relatively high moisture content for a period of three weeks, show a different moisture retention at the various humidities than was shown during hydration.

5. The absorptive properties of milk powder were found to be altered by excessive heating and previous saturation.

6. Milk powders with variable fat content are shown to possess different capacities for moisture absorption and retention. The

absorptive ability decreases with increased fat content and correspondingly lower protein content.

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SWEETENED CONDENSED MILK

III. IN A TOTAL SOLIDS RESIDUE WHAT IS THE FORM OF LACTOSE?*

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AND

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Where reference is made to lactose in the literature there is much confusion as to which is meant—the hydrate or anhydrous form. This sugar under ordinary conditions crystallizes as $C_{12}H_{22}O_{11} \cdot H_2O$ and this is the form in which it appears on the market and in the laboratory generally. In many cases, however, calculations are based on a molecular weight corresponding to $C_{12}H_{22}O_{11}$, though perhaps generally the molecule of water is taken into consideration. For instance, the figure 52.5 is given in most texts as the specific rotation of lactose; this is calculated on the basis of the hydrate. In quantitative data there is, of course, a difference of 5 per cent depending on which form is used.

Lactose is sometimes determined in condensed milk by subtracting the sum of the other solids from the total dry matter; in this case it is important to know whether the hydrous or anhydrous form is present in the dry matter. But this work was carried out particularly because it was necessary that this point be cleared up before some of the calculations could be made that are involved in the next article of this series.

It is known that lactose hydrate is very stable, the molecule of water being driven off only at about 130°C. On the other hand, data has been presented which shows that the evaporation of an aqueous solution of lactose above 93°C. yields the anhydrous

* Received for publication July 20, 1925.

[1] Work here recorded was done when the senior author was on the staff at Cornell University.

form (1). In the determination of total solids in condensed milk, usually a water solution is evaporated on a water or steam bath, or hot plate. It would be expected, therefore, that the conditions would be right for the production of the anhydrous form.

Two experiments were carried out: In one an aqueous solution of pure lactose was evaporated and the residue dried under conditions similar to those observed in the total solids determination. In the other, a known amount of lactose was added to a condensed milk solution and the determination carried out in the same way; this result compared with the solids residue obtained from the condensed milk alone gave data from which could be determined the condition of the lactose in the residue.

The lactose used in these experiments was of highest purity containing 0.2 per cent hygroscopic moisture. It showed the theoretical specific rotation.

The procedure of the A. O. A. C. for the determination of dry matter in sweetened condensed milk was followed in all cases, employing ignited sea sand for drying residues.

EXPERIMENT 1

Two lactose solutions were prepared containing (*a*) 5 grams and (*b*) 10 grams in 100 cc. Ten cubic centimeter portions of these solutions were carried through the total solids determination in quadruplicate. The following weights of residue were obtained:

Solution 1. 0.4721, 0.4722, 0.4728, 0.4721 gram.
Solution 2. 0.9449, 0.9452, 0.9459, 0.9469 gram.

Since the lactose used contained 99.8 per cent $C_{12}H_{22}O_{11}$, there should have been in the first set of residues 0.4740 and in the second 0.9481 gram if the anhydrous form were present. These figures are very close to those obtained experimentally. The experimental results being somewhat lower than the theoretical is perhaps to be accounted for by a slight decomposition of the lactose while drying.

EXPERIMENT 2

Solutions containing 20 grams fresh condensed milk in 100 cc. were prepared (M). Two solutions of lactose containing 5 grams (A) and 10 grams (B) in 100 cc. were used as a convenient means of adding the lactose. The results obtained are given in table 1.

TABLE 1

	WEIGHT OF RESIDUE	
	(1)	(2)
	grams	*grams*
10 cc. M + 10 cc. A	1.9336	1.9398
10 cc. M	1.4543	1.4633
Difference	0.4793	0.4765
10 cc. M + 10 cc. B	2.4136	2.4189
10 cc. M	1.4543	1.4633
Difference	0.9593	0.9556

Since the actual added lactose ($C_{12}H_{22}O_{11}$) in the first series was 0.4740 gram and in the second 0.9481 gram, it is clear that in the process of evaporating and drying, nearly all the sugar appeared in the residue in the anhydrous form. Where the smaller addition was made (solution A) the anhydrous state was more nearly reached than with the larger addition. It may be concluded, therefore, that in condensed milk where the content of lactose is still less, this sugar appears in the total solids residue in the anhydrous form.

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THE INFLUENCE OF THE PERIOD OF HEAT ON MILK PRODUCTION

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It is generally believed that oestrum, or the period of heat has a depressing influence on the production of dairy cows. However, there is little direct evidence by which the validity of this can be tested.

RÉSUMÉ OF PREVIOUS WORK

It was reported by Hooper (1) that in 54 records obtained from cows kept for three years that the oestral period caused a considerable variation in production with some cows while with others it seemed to have but little effect. Later Hooper and Brown (2, 3) found from the records of 29 cows that there was an average decrease of 0.1 pound in fat and 1.5 pounds in milk production on the day of most evident heat. Some cows showed an increase in production however while others showed no variation.

DATA PRESENTED

The data summarized and presented in table 1 were collected during the years 1907 to 1921 inclusive from the herd at this station. Not all heat periods are included, as it was felt best to collect the records from the dates of breeding only. Consequently the day on which a cow was bred was looked on as the day of most evident heat and the average milk production on the days of most evident heat was obtained and compared with the average production on each of the three days preceding and following it. In all a summary of 868 cases is given.

It will be noticed that on each of the three days preceding and following the days of breeding the average milk production is higher than on the day of breeding; the highest average production being two days before breeding while the others ran at an apparently normal rate with the exception that on the day follow-

ing the date of breeding the production was also somewhat lower than on the other days included.

TABLE 1

Influence of oestrum on production

GROUP	NUMBER ON COWS	NUMBER OF HEAT PERIODS	DAYS BEFORE AND AFTER BREEDING WITH AVERAGE PRODUCTION						
			3	2	1	0	1	2	3
			pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Holsteins	28	215	30.9	31.2	30.8	30.1	29.8	30.6	30.7
Jerseys	32	198	18.0	18.2	18.2	17.7	17.8	18.2	18.1
Guernseys	28	155	20.3	20.6	20.3	19.9	20.3	20.5	20.6
Ayrshires	14	72	25.2	25.6	25.2	24.8	24.6	25.0	25.2
Scrubs	8	49	14.9	15.4	15.2	14.7	14.7	14.9	15.0
First Grades	16	80	17.0	16.6	17.0	16.3	16.5	16.7	16.9
Second Grades	19	99	16.8	16.5	16.7	15.8	15.9	16.4	16.7
Total	145	868	21.8	22.0	21.8	21.2	21.3	21.7	21.8

TABLE 2

Variations in the influence of oestrum on production in the case of Holstein cow 44

DAYS BEFORE AND AFTER BREEDING	MILK PRODUCTION IN PERIODS		
	I	II	III
	pounds	*pounds*	*pounds*
3	38.5	35.6	38.7
2	37.9	34.5	40.2
1	39.0	38.1	42.1
0	37.6	40.4	41.5
1	43.5	42.1	40.1
2	42.3	42.2	43.6
3	44.3	39.5	43.6
Average for 6 days before and after breeding	40.9	38.7	41.5
Percentage income over day of breeding	−8	4	0

This increase in production on the second day before breeding as compared with that on the day of breeding is only 4 per cent for the total group considered. This is not a large variation but

when it is considered as being from a large number of animals, and that a similar increase occurs in each group of the animals then it is perhaps safe to deduce that there is some reason for the production being high two days before breeding and low on the day of breeding and that following it as compared with the production on other days near that time.

One possible explanation is that as the period of heat starts some galactogogic hormone is produced in greater quantities, either as a purely incidental process, or in an effort to stimulate production at this time so as to compensate for the lowered production two days later.

Though it appears that there are fairly uniform changes in production around the period of heat in the case of large groups of cows, yet individual cows vary considerably and an individual cow may show wide variations in her behavior from one heat period to another.

This is well illustrated in the case of the Holstein cow 44 in the College Herd at three breeding dates.

In this case it will be found that the cow 44 showed all the variations possible in production at different times of breeding. This indicates variations in production at the time of heat which can not be accounted for.

SUMMARY

From the data presented here it would appear that:

1. There is a decrease in milk production on the day of breeding and the day following.
2. An apparently compensating increase takes place two days before breeding.
3. Individual cows show very wide differences in their production at this time.
4. Wide variations in behavior may be expected between different heat periods with the same individual.

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FACTORS INFLUENCING THE VISCOSITY OF CREAM AND ICE CREAM*

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It is a well known fact that pasteurization, aging, homogenization and the amount of binder used all have an influence upon the viscosity of the product. Pasteurization brings about a decrease in the viscosity of the cream or ice cream mix to such an extent that if the product were to be made into ice cream at once difficulty would be experienced in obtaining the desired overrun and the texture would be poor. This difficulty may be overcome by aging the cream or mix for twenty-four hours or longer.

Trade preparations, known as "improvers" are frequently used to hasten the ripening and bring about the desired viscosity in a few hours if necessary. The increase in viscosity brought about by the use of an "improver" is probably due, in some cases at least, to coagulation. However, when no "improver" is used the increase in viscosity is probably not due to coagulation, but is probably due to physico-chemical changes. If the whole mix is pasteurized and homogenized the increase in viscosity is due, in part at least, to the presence of the gelatine. However, the increase in viscosity brought about in pasteurized and homogenized cream is quite pronounced. Just what factors are responsible for this are not definitely known although several theories (1) have been advanced to explain this phenomenon.

According to one theory it is due to the knitting together of the colloidal particles in the cream thus restoring the viscosity. A second theory is that this increase in viscosity is due to the hydration of the proteins while held at the low ripening temperature. A third theory is that it is due to enzymatic action, while a fourth theory is to the effect that the increase in viscosity is due to a greater clumping together of the fat globules during aging.

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The viscosity of cream generally increases with age. The rate of increase in viscosity of an homogenized cream is much greater than that of a cream pasteurized but unhomogenized held under the same conditions. The increase of viscosity in cream immediately after homogenization over the same cream before homogenization is due to the taking up or fixing of more of the milk serum. This is brought about by the breaking up of the fat globules resulting in an increase in the total surface area of the fat globules.

The microscopical appearance of the fat globules differ exceedingly from that of a pasteurized sample. The latter when examined under the microscope shows the globules spread out evenly over the field and separated from each other, although in some cases globules will be seen touching each other. The fat globules in the homogenized cream present an entirely different appearance. The globules are about one-tenth the original size and are clumped together in clusters, varying in size from very small clumps of three or four globules to large clumps of several hundred. This clumping of the fat globules suggested the idea that aging of the cream causes the fat globules to come together in larger clumps. If this is the case it is probable that the increase of viscosity is due to the enclosure of serum in these clumps. Bancroft (1) states that "of particles agglomerate loosely into spherical masses, the viscosity will increase because the water in the voids inside the spherical agglomerates no longer counts as free water."

The work herein reported represents an attempt to determine whether or not the clumps of globules did increase in size during a period of storage and if a high viscosity could be attributed to a greater grouping together of the fat globules.

THE INFLUENCE OF PASTEURIZATION, HOMOGENIZATION AND AGING UPON THE VISCOSITY OF CREAM

Methods

The cream used was sweet cream of less than 0.20 per cent acidity and standardized to 18 per cent butter fat with whole

milk. Pint samples of the cream were taken after pasteurization and immediately after homogenization. The viscosity of each sample was determined and a microscopical examination made of the fat globules. These samples were then placed in storage and examined at intervals of twenty-four hours.

It was found necessary to dilute the cream in order to examine it under the microscope. The following method, which could be closely adhered to from day to day, was adopted. Nessler tubes, graduated to hold 50 cc. were filled to the 50 cc. mark with distilled water. Two drops of each sample of cream were added to separate tubes from a 1 cc. pipette, the same pipette being used from day to day. The tubes were then corked tightly and inverted slowly and the mixture allowed to run to the opposite end of the cylinder. The cylinder was then brought back slowly to its upright position three times thus mixing the cream thoroughly through the water. A drop of this mixture was then placed on a slide for observation.

In one instance in the first part of this experiment the viscosities were secured with the Scott viscosimeter. The cream to be tested was brought to a temperature of 17°C. and 200 cc. transferred to the viscosimeter. The length of time required for 50 cc. of the cream to run through the aperture was determined by means of a stop watch. The specific viscosity was calculated by dividing the time viscosity by the time required for 50 cc. of distilled water at the same temperature to run through the viscosimeter.

The remaining viscosities were obtained with the Doolittle Torsion Viscosimeter. Two determinations were always made; one by rotating the wire to the right; the other to the left, and the average of the two readings taken.

A description of the field observed under the microscope was decided upon as the best method of keeping a record of the appearance of the clumps of fat globules.

Results secured

The data secured on the viscosity of the pasteurized cream and homogenized cream and the appearance of the fat globules under

the microscope are presented in table 1. A study of the data in these tables reveals the fact that the viscosity of pasteurized cream shows very little increase during aging. In five of the six trials the pasteurized cream had a slightly higher viscosity at the holding period than when fresh although there was not a steady increase from the time the first reading was taken. The tendency seemed to be for the viscosity to remain the same or drop somewhat during the first twenty-four hours and then to increase slightly as the aging progressed. The appearance of the fat globules in the pasteurized sample was practically constant in all the trials in that the globules were separate and did not change upon aging. In experiment 2 the pasteurized cream when forty-eight hours old had a clump of three or four globules here and there on the microscopic field under observation. The fact that no clumping of the fat globules was observed in the pasteurized sample does not prove that it did not occur. The probability is that if clumps are formed the globules do not cling together as tenaciously as in homogenized cream and the mixing of the cream and water would break up these clumps if any were present.

The results obtained for the homogenized cream proved rather contradictory in that the viscosity did not always increase during aging. The data obtained in experiments 1 and 2 show that there was a steady rise in the viscosity at the end of each twenty-four hours. The data obtained in experiment 3 show a decrease in viscosity at the end of twenty-four hours but an extremely high viscosity after forty-eight hours. The data secured in experiments 4 and 6 show a slow decline in viscosity from the fresh sample up to and including the seventy-two hour old sample. Experiment 5 shows a falling off in viscosity up to the end of the forty-eight-hour period and then an increase so that the reading taken at seventy-two hours was higher by 1.75° than when fresh. In general there was a direct relationship between the appearance of the fat globules and the viscosity. That is, where the viscosities increased, the clumps of fat globules were larger, and where the viscosity decreased, the size of the clumps remained the same as when the sample was fresh.

TABLE 1

The influence of aging upon pasteurized cream and upon pasteurized and homogenized cream

EXPERIMENT		PASTEURIZED	HOMOGENIZED	PASTEURIZED	HOMOGENIZED	PASTEURIZED	HOMOGENIZED	PASTEURIZED	HOMOGENIZED
1	Specific viscosity	1.22	9.01	1.22	12.62	1.31	Would not run	1.33	Would not run
	Age	Fresh	Fresh	24 hours	24 hours	48 hours	48 hours	72 hours	72 hours
	Appearance of fat globules	Separate and spread over field	Several large clumps	Same as fresh	Many large clusters	No distinct clumping	Fat clumps large and numerous	No distinct clumping	Clumps very large and numerous
2	Viscosity in degrees retardation	7.00	110.00	6.75	126.25	7.25	Too viscous to get reading		
	Age	Fresh	Fresh	24 hours	24 hours	48 hours	48 hours		
	Appearance of fat globules	Separate and spread over field	Globules clumped together	Same as fresh	Few large clumps	1 or 2 clumps of 3 or 4 globules	Clumping increased clusters larger		
3	Viscosity in degrees retardation	9.5	169.00	9.25	110.00	10.00	345		
	Age	Fresh	Fresh	24 hours	24 hours			72 hours	72 hours
	Appearance of fat globules	No clumping of fat globules	Many clumps	No clumping	Many clumps			No change	Many large and medium sized clumps
4	Viscosity in degrees retardation	10.56	49.25	9.00	48.75	9.75	46.40	9.75	45.00
	Age	Fresh	Fresh	24 hours	24 hours	48 hours	48 hours	72 hours	72 hours
	Appearance of fat globules	Globules separate	Clumps very small	No change	Same as fresh	No change	No change	No change	No change

5	Viscosity in degrees retardation	9.50	142.75	9.50	140.75	9.50	129.50	10.50	144.50
	Age	Fresh	Fresh	24 hours	24 hours	48 hours	48 hours	72 hours	72 hours
	Appearance of fat globules	Fat globules separate	Small cluster	Fat globules separate	Same as fresh	No change	No increase in size of clumps	No change	No change
6	Viscosity in degrees retardation	8.25	84.75	8.00	80.00	8.50	78.50		
	Age	Fresh	Fresh	24 hours	24 hours	48 hours	48 hours		
	Appearance of fat globules	Globules separate	Medium sized clumps	No change	No change	No change	No change		

THE EFFECT OF AGITATION UPON VISCOSITY

Since the results obtained above indicate that with an increase in viscosity there is a greater clumping together of the fat globules to which can be attributed the higher viscosity, for the reason that as the clusters grow larger more serum is enclosed by them resulting in an increase in viscosity, it was decided to carry the work farther and attack the problem from another angle. During the freezing process the mix is subjected to violent agitation, which would naturally be expected to break up the clusters of fat globules. If the supposition that the clumping together of the fat globules increased the viscosity is correct then the reverse should also be true; namely, if the fat clumps are broken up the viscosity should decrease.

Methods

Samples were taken of homogenized cream after aging and of the mix before running it into the freezer. The freezer used in this work was a 40-quart brine freezer and the brine was made with ice and salt. A Manton-Gaulin homogenizer with a capacity of 60 gallons per hour was used for homogenizing.

The formula adopted for the ice cream was as follows:

42 pounds 18 per cent cream
8 pounds sugar
4 ounces gelatin
4 ounces vanilla

During the freezing process samples were drawn from the freezer at the end of two, four, six, eight, and ten minutes. These consecutive samples were examined under the microscope and their viscosities determined with a Doolittle Torsion Viscosimeter, after carefully warming to 17°C. to allow the enclosed air to escape.

In the microscopic examination seven Nessler tubes were used and the dilutions prepared as previously explained. A glass slide, large enough so that a drop of all seven dilutions could be arranged in sequence upon it, was used. This allowed of a rapid change under the lens from one drop to another and a more

TABLE 2

The influence of agitation upon the viscosity of cream and ice cream mix

EXPERIMENT		CREAM	MIX	WHIPPED 2 MINUTES	WHIPPED 4 MINUTES	WHIPPED 6 MINUTES	WHIPPED 8 MINUTES	WHIPPED 10 MINUTES
1	Viscosity in degrees retardation	141.75	92.75	24.50	18.50	18.00	16.50	14.50
	Appearance of fat globules	A few large clumps, many medium and small clumps	Few large clusters many medium and small clumps	3 or 4 large clusters, others small	No big clumps, many small clumps	A few small clumps, mostly individual globules	Only a very few, very small clumps	About the same on 8 minutes sample
2	Viscosity in degrees retardation		39.50	39.00	17.25	13.25	13.50	10.75
	Appearance of fat globules		No large clumps, many medium and small clumps	Fewer clumps, more individual globules	Clumps fewer and smaller	Practically no medium sized clumps but many small ones	Clusters very small, many individual fat globules	Scarcely a clump left
3	Viscosity in degrees retardation	154.00	89.00	21.00	Lost	16.25	12.50	10.50
4	Viscosity in degrees retardation	240.00	85.50	14.00	10.75	10.00	9.50	8.75
5	Viscosity in degrees retardation	154.50	33.25	14.25	11.25	10.75	10.50	9.25
6	Viscosity in degrees retardation	134.25	29.25	18.75	15.50	15.75	13.00	11.25
	Appearance of fat globules	The appearance of the clumps in the last four runs was similar to the other runs. The cream had large clusters present and as the viscosity decreased so did the size of the clumps until at the end of the ten minutes scarcely any clumps were to be seen in the field						

accurate comparison of the clumps in the different samples was possible.

Results obtained

The data secured on this part of the problem are presented in table 2. The viscosity droped consistently in each sample taken with the exception of the eight-minute sample in experiment 2, where the viscosity of the eight-minute sample was 0.25 degree higher than that of the six-minute sample. However, since the difference is so small and in all other cases there was a consistent fall in viscosity we are justified in concluding that there is in general a lowering of the viscosity brought about by agitation. The greatest drop was from the cream to the mix, the stirring necessary to mix the sugar, gelatine, and vanilla evidently being disasterous to the viscosity. That such is the case should be borne in mind when preparing the mix and unnecessary stirring of the cream avoided. If the whole mix is pasteurized and homogenized this factor is not so important.

SUMMARY

An effort was made to discover whether or not the increase in viscosity of cream during aging could be attributed to an increase in the size of the clumps of fat globules. Samples of pasteurized and homogenized cream were collected and the viscosity taken every twenty-four hours, and at the same time a microscopic examination of the fat globules was made. In three of the trials the viscosity increased during aging, in two it decreased and in the remaining one it was lower at the end of twenty-four hours and forty-eight hours but was slightly higher after seventy-two hours than when fresh. The appearance of the clumps of fat globules seemed to bear a fairly definite relation to the viscosities, in that in those experiments where the viscosity increased, the size of the clusters apparently increased also, while in the trials where no increase was encountered the clumps showed no indication of becoming larger during the holding period.

The influence of agitation on the viscosity and the size of the clumps of fat globules was studied by collecting samples of the

aged cream, the same cream after the sugar, gelatine, and vanilla had been stirred in and of the mix after two, four, six, eight, and ten minutes agitation in the freezer. These samples were then examined under the microscope and viscosity determinations made. From the results obtained it is evident that agitation causes a marked reduction in the viscosity and that there is a corresponding reduction in the size of the cluster of fat globules.

CONCLUSIONS

1. Cream in some cases showed an increase in viscosity upon aging and in other instances did not. The clumps of fat globules were larger in those cases where there was a rise in viscosity.

2. Agitation caused a decided reduction in viscosity of cream, with an accompanying reduction in the size of the clumps of fat globules.

3. The results of this investigation indicated that the increase in viscosity, noted in cream during aging, is attributable to a greater grouping together of the fat globules with its attending fixation of a part of the free serum.

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A STUDY OF CALCIUM AND PHOSPHORUS BALANCES WITH DAIRY CATTLE*

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The results of many years of study by numerous investigators and many practical aspects of the problem have developed an increasing interest in the utilization of calcium and phosphorus by dairy cattle.

The limited ability of the dairy cow to utilize the mineral constituents of various rations was demonstrated in series of experiments by Forbes (1). Normal dry winter rations were fed and variously included, timothy, clover or alfalfa hay and in some cases corn silage. Negative calcium balances were obtained in all cases where the daily milk production exceeded 10 pounds, the losses being less with clover hay and alfalfa than with timothy hay. In most cases the phosphorus balances were negative.

Hart and associates (2) reported an appreciable retention of calcium when alfalfa hay that had been cured under caps was fed to liberally milking cows. A more liberal storage resulted from the use of fresh green alfalfa. Positive phosphorus balances accompanied the storage of calcium. It was thought that the quality of the roughage determined the degree of calcium assimilation, by the term quality being meant the relative degree of destruction in the curing process of the unknown factors affecting calcium assimilation.

Steenbock and associates (3) reported from results obtained with rats that alfalfa cured in the dark was very rich in vitamin A, even 0.5 per cent supporting normal growth when the anti-

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Note: The author wishes to express his appreciation to Dr. L. A. Maynard and W. E. Krauss for many valuable suggestions and assistance given in conducting the experimental work.

rachitic factor was supplied in the form of light, otherwise 4 per cent being required. When cured in the sun, exposed to dew and rain, vitamin A was destroyed but an antirachitic activation of certain substances in the alfalfa was suggested.

In later work Hart and associates (4) reported that negative calcium and phosphorus balances were obtained with liberally milking cows on alfalfa hay that had been cured in the windrows for four days. Greater losses were obtained on timothy hay. In further work (5) it was found that on rations including fresh green plant tissue, such as June grass and white clover, negative calcium balances were obtained. Inquiry into the previous nutritional history of the cows accounted for the negative balances and a repetition of this experiment taking into account this factor, showed that liberally milking cows were not maintained in calcium equilibrium on the character of green grasses fed unless a supplement of bone meal was added. In this experiment appreciable positive phosphorus balances accompanied losses of calcium.

Hart and associates (6) have more recently reported that upon daily exposure for twenty minutes to the emanations from a mercury quartz vapor lamp negative calcium balances were changed to positive balances in two mature lactating goats and one mature dry goat which had been brought into negative calcium balance or equilibrium on a ration deficient in the antirachitic factor.

Meigs and associates (7) concluded from their own results and a survey of previous balance experiments that the results of such experiments are such as to indicate that the experimental conditions usually interfered with the calcium assimilation. Evidence from balance experiments was also presented to show that the assimilation of phosphorus and probably calcium was favored by the addition of disodium phosphate to the grain ration and feeding the grain and hay of the ration on alternate days. Marked increases in the milk yield in the Beltsville herd were noted when this procedure was practiced (8).

Miller and associates (9) have reported an experiment in which the addition of bone meal to a ration including red clover hay, permitted a storage of calcium and phosphorus.

A further report by Miller and associates (10) dealt with results obtained after the same animals had been maintained under successful lactation for ten months and were still farrow and producing about 20 pounds of milk daily. A storage of calcium and phosphorus resulted on the basal ration which included clover hay, corn silage and grain. Supplements of bone meal and kale separately increased the storage of calcium while with bone meal, phosphorus storage was increased and with kale phosphorus storage was decreased.

Monroe (11) has presented data showing that cows on high protein rations stored calcium while those on lower protein rations lost this element. Combinations of clover and timothy hays were fed, the proportion of clover to timothy being higher in the high protein rations. Beet pulp, carrying a liberal supply of calcium was a constituent of the rations. Some of the results indicated that the narrow rations used would permit a greater phosphorus retention than the wide rations.

In further work Monroe and Perkins (12) have shown that on the same rations cows which had previously had pasture were better able to assimilate calcium than cows which had been continually on dry feed while the reverse was true in the case of phosphorus. The effect of feeding distilled water as compared to that ordinarily offered the herd was determined, there being apparently slight difference in the results.

For the past two years a study of nitrogen balances with dairy cattle has been in progress at this station[2] and in conjunction with this work it was thought worth while to determine the balances of calcium and phosphorus in as much as the roughages and rations used permitted interesting studies of different phases of the problems concerned in the assimilation of calcium and phosphorus. The results of this study are recorded in this paper.

EXPERIMENTAL

The trials

The experiments reported in this paper consist of four trials in which the balances of intake against outgo of calcium and

[2] The results of these studies will be published in the near future by L. A. Maynard, W. E. Krauss and the author.

phosphorus were determined. Trials 1 and 2 were conducted in December, 1923, and January, 1924, and trials 3 and 4 in November and December, 1924. In trials 1 and 4 clover hay was the roughage fed and in trials 2 and 3 timothy hay was used. In 1923 the clover hay trial preceded and in 1924 followed the timothy hay trial.

Each trial consisted of three periods: A transition period in which the cows were accustomed to the experimental quarters and fed the roughage characteristic of the trial, but only an approximate grain mixture. There followed a preliminary period in which they received accurately weighed out amounts of the feeds and then a collection period when the excreta was collected by attendants. The transition periods were seven to ten days long, the preliminary periods four days to a week long, and the collection periods in trials 1 and 2, twelve days long, and in trials 3 and 4, fourteen days long.

A point of interest that may affect the results obtained is that the cows were exposed to direct sunlight periodically throughout the experiment. The actual preliminary feeding and collection of excreta was conducted in a north room of a basement barn where there was no exposure to sunlight, but during the transition and preliminary periods the cows were turned out in a courtyard for approximately two hours daily when the weather permitted, and during the collection period they were exercised at least every other day in this courtyard or in the vicinity of the barn. These exercise periods were from twenty to thirty minutes long, the cows being accompanied by attendants equipped for collection of any voided excreta. Whether or not this procedure materially affected the calcium assimilation is a question, but it is thought well to point out that the cows were exposed to some direct sunlight and that some calcium assimilation may have resulted from it. When weather conditions permitted the cows were removed from the stable every other day for the purpose of weighing them.

The cows

The animals used were mature pure bred Holstein cows. The stages of the lactation and gestation periods covered are given in

table 1. Animals 1 and 4 were the same. All of the cows were good feeders with the exception of no. 2 in trial 2, when for two days she refused a considerable amount of feed.

Previous to starting the experiment in 1923 the cows were in good condition, having been on a good grain ration containing 1 per cent each of bone meal and calcium carbonate and having received an excellent quality of mixed hay but rather poor corn silage that contained but few ears.

TABLE 1

Stages of lactation and gestation periods covered and average daily milk yields

TRIAL NUMBER	COW NUMBER	DISTINGUISHING FEATURE OF RATION	PERIOD OF LACTATION	PERIOD OF GESTATION	AVERAGE DAILY MILK YIELD	AVERAGE WEIGHT OF COWS
			day	*day*	*pounds*	*pounds*
1	1		101–112	3–14	48.66	1,359
	2	Clover	238–249	Not bred	39.45	1,187
	3	Hay	88– 99	4–15	54.92	1,451
2	1		132–143	34–45	46.44	1,372
	2	Timothy	269–280	13–24	35.51	1,167
	3	Hay	119–130	35–46	53.66	1,447
3	4		74– 87	Not bred	51.31	1,369
	5	Timothy	63– 76	Not bred	48.05	1,281
	6	Hay	188–201	Not bred	37.65	1,301
4	4		99–112	6–19	49.00	1,349
	5	Clover	88–101	6–19	46.25	1,247
	6	Hay	213–226	1–14	34.91	1,279

In 1924 before being placed on the experiment the cows had been receiving a good grain ration in excess of their requirements. They had been getting 8 pounds daily of a mixture of clover and timothy hays and 60 pounds of poor quality corn silage. They had been receiving no minerals.

There is no reason to believe that in either year any of the animals were in a bad state of mineral or vitamin depletion, having not been long off pasture and having since received fair quality rations previous to starting the experiments. It can be said that the previous nutritional history of the cows was probably better than that of cows subjected to average practical

conditions, although they had not been receiving the best quality of hay.

THE FEEDS AND RATIONS

The feeds used in the experiments were such as are commonly used in winter feeding. The ingredient composition of the various grain mixtures is given in table 2. The calcium and phosphorus contents of the feeds is given in table 3. The clover

TABLE 2

Ingredients of grain mixtures, average daily rations consumed and average daily milk produced

TRIAL	COW	COMPOSITION OF GRAIN MIXTURE				TOTAL GRAIN	TIMOTHY HAY	CLOVER HAY	SILAGE	SALT	MILK	WATER
		Corn meal	Ground oats	Wheat bran	Oil meal							
		per cent	*per cent*	*per cent*	*per cent*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
1	1	59.67	20.17	13.44	6.72	8,358		5,444	18,144	35	22,073	
	2	45.19	27.41	18.27	9.13	6,276		5,226	18,144	35	17,895	
	3	54.65	22.67	15.12	7.56	10,134		5,225	17,517	35	24,910	
2	1	35.29	32.36	21.57	10.78	8,970	5,444		18,144	45	21,067	
	2	25.19	37.40	24.94	12.47	6,794	4,536		12,096	45	16,107	
	3	26.79	36.61	24.40	12.20	10,722	5,444		18,050	45	24,341	
3	4	33.42	33.29	22.19	11.10	8,934	5,460		18,144	60	23,274	48,318
	5	35.22	32.39	21.59	10.80	7,146	5,460		18,144	60	21,796	40,170
	6	40.79	29.61	19.73	9.87	7,244	4,527		17,085	60	17,079	39,334
4	4	36.89	63.81			8,544		5,460	18,144	60	22,228	46,893
	5	61.20	38.80			7,224		4,540	18,144	60	20,977	37,412
	6	65.47	34.53			6,438		4,540	16,689	60	15,833	40,442

and timothy hays used in trials 1 and 2 were judged as Federal grade number 2 and those used in trials 3 and 4 as number 1. The clover hay particularly in trial 4 was of excellent quality. No particular care was taken in the curing process, however, none of the clover was excessively exposed to the elements in curing.

In no case was the silage of excellent quality. It was for the most part corn silage containing sunflowers and very few corn

ears. At the beginning of trials 2 and 4 new silos were opened and for several feedings the silage was not of good quality, it being necessary to exercise care in the feeding in order to keep the cows on feed.

The composition of the grain mixture to be used was ascertained by determining the probable milk yield of the cows by means of the transition period when they were fed a basal grain mixture together with silage and the roughage characteristic of the trial.

In most cases the milk production was actually overestimated so that the cows received rations slightly in excess of their expected requirements based on their performance during the transition period.

TABLE 3

Calcium and phosphorus content of feeds as weighed and fed

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4	
	Ca	P	Ca	P	Ca	P	Ca	P
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Silage	0.1590	0.0657	0.1573	0.0923	0.0983	0.0537	0.0789	0.0409
Clover hay	1.1123	0.2208					1.1275	0.2790
Timothy hay			0.3778	0.2238	0.3131	0.1692		
Grain, cow 1	0.0925	0.5087	0.1347	0.7285				
Grain, cow 2	0.1073	0.6041	0.1513	0.6440				
Grain, cow 3	0.0952	0.5751	0.1362	0.8615				
Grain, cow 4					0.1206	0.7252	0.1054	0.3241
Grain, cow 5					0.1138	0.6600	0.0811	0.3528
Grain, cow 6					0.1190	0.6643	0.0635	0.3182

The rations were made up to supply each cow with the upper limit of total digestible nutrients specified by the Morrison standard, but in order to satisfy conditions desired for the nitrogen balance study the amount of protein fed was necessarily lower than that specified. The protein intake was calculated to be the maintenance requirement plus digestible protein equal to 120 per cent of the protein in the milk produced.

In making up the rations it was desired to feed the same amount of silage and hay in all cases but to vary the composition of the grain mixture to adjust the protein intake to the desired level. Therefore with clover hay a low protein grain mixture was fed and vice versa with timothy hay. The high protein content

TABLE 4

Average daily balances of calcium and phosphorus

		cow 1		cow 2		cow 3	
		Ca	P	Ca	P	Ca	P
		grams	grams	grams	grams	grams	grams
	Silage	28.849	1.192	28.849	1.192	27.852	1.151
	Clover hay	60.554	12.020	58.129	11.539	58.118	11.537
	Grain	7.731	42.517	6.734	37.913	9.648	58.281
	Total	97.134	55.729	93.712	50.644	95.618	70.969
Trial 1	Milk	24.854	19.071	20.293	15.247	23.067	22.270
	Urine	0.624	0.211	0.900	0.282	0.542	0.226
	Feces	69.443	41.357	73.354	41.596	74.394	42.517
	Total	94.921	60.639	94.547	57.125	98.003	65.013
	Balance	+2.213	−4.910	−0.835	−6.481	−2.385	+5.956
	Silage	28,541	1.675	19.027	1.116	28.393	1.666
	Timothy hay	20.567	12.184	17.137	10.152	20.567	12.184
	Grain	13.572	57.767	9.152	49.494	14.603	92.370
	Total	62.680	71.626	45.316	60.762	63.563	106.220
Trial 2	Milk	25.154	21.509	19.908	15.382	26.215	24.536
	Urine	1.130	0.211	1.357	0.419	0.394	0.254
	Feces	46.202	54.121	37.030	47.658	50.569	70.654
	Total	72.486	75.841	58.295	63.459	77.178	95.444
	Balance	−9.806	−4.215	−12.979	−2.697	−13.615	+10.776
		cow 4		cow 5		cow 6	
	Silage	17.836	0.974	17.836	0.974	16.795	0.917
	Timothy hay	17.095	9.238	17.095	9.238	14.174	7.660
	Grain	10.774	64.789	8.132	47.163	8.620	48.121
	Water	4.300		3.575		3.501	
	Total	50.005	75.001	46.638	57.375	43.090	56.698
Trial 3	Milk	26.974	23.786	22.254	22.232	19.675	17.660
	Urine	0.958	0.237	1.818	0.198	1.676	0.258
	Feces	32.786	57.275	35.092	46.933	27.174	47.178
	Total	60.718	81.298	59.164	69.363	48.525	65.096
	Balance	−10.713	−6.297	−12.526	−11.988	−5.435	−8.398
Trial 4	Silage	14.316	0.742	14.316	0.742	13.168	0.683
	Clover hay	61.562	15.233	51.189	12.667	51.189	12.667

TABLE 4—*Continued*

		cow 4		cow 5		cow 6	
		Ca	P	Ca	P	Ca	P
		grams	*grams*	*grams*	*grams*	*grams*	*grams*
Trial 4	Grain	9.005	27.691	5.859	25.486	4.088	20.486
	Water	4.174		3.330		3.599	
	Total	89.057	43.666	74.694	38.895	72.044	33.836
	Milk	25.540	19.516	21.271	19.425	17.749	15.453
	Urine	1.056	0.288	1.142	0.230	2.359	0.234
	Feces	67.436	32.863	60.872	25.480	58.280	28.813
	Total	94.032	52.667	83.285	45.135	78.388	44.500
	Balance	−4.975	−9.001	−8.591	−6.240	−6.344	−10 664

of the clover hay used in trial 4 required that the oil meal and wheat bran be omitted from the grain mixture. This ration was therefore comparatively high in calcium and low in phosphorus as can be seen from table 3.

The grain of the ration was fed three times daily at milking time, the hay and silage being fed at night and morning. Very little feed was refused by any of the animals. However, any residue was accounted for and after being dried out in a steam oven was fed back to the cow if possible.

During trials 1 and 2 the cows received distilled water and in trials 3 and 4 tap water such as ordinarily fed to the herd was used. All water taken by the cows was weighed.

The methods of analysis used were the official methods of the Association of Official Agricultural Chemists with the exception that after ashing and dissolving in dilute hydrochloric acid, calcium was determined by the McCrudden method (13) modified to use the potassium permanganate titration (14).

DISCUSSION

Calcium balances

The balances of calcium and phosphorus are given in table 4. All of the calcium balances are negative except one in which a slight storage of this element took place with cow 1 in trial 1 on

clover hay. In general smaller negative balances were obtained when clover instead of timothy hay was fed as the roughage. These results are in agreement with the findings of other investigators. The only exception occurs in the case of cow 6 which lost less than one gram more calcium in trial 4 than in trial 3. In general probably due to advancement in the lactation period the losses of calcium by this animal were low. In addition she suffered some disturbance due to breeding on the morning that trial 4 was started and had difficulty in consuming her allotment of silage for several days.

As has been pointed out, the silage in trials 3 and 4 was of poor quality and not as good as that used the previous year. Consequently the calcium intake was considerably lower in the last two trials. What effect the quality of the silage would have from the standpoint of both its content of calcium and the antirachitic factor is questionable. From this work and also the results of Forbes and Hart such a consideration does not seem to be important although it may have a small effect on calcium assimilation.

A comparison of the calcium balances obtained in trials 1 and 4 may indicate the possibility of decreased calcium assimilation in trial 4 due to the low phosphorus content of the ration used in that trial. Such an adjustment of the rations was made necessary by the nitrogen balance studies due to the high protein content of the clover hay that was used.

No difference is noted of the effect of feeding tap water in trials 3 and 4 instead of distilled water as in the first two trials except a possibly higher outgo of calcium in the urine in some cases. This is in general in accord with a recent report by Monroe and Perkins (12). The calcium content of the tap water was low but the intake of this element was accounted for. Only a trace of phosphorus could be detected in the tap water.

The previous nutritional history of the cows each year may have influenced the results obtained. This factor may have been responsible for the relatively low losses and for one case of storage in trial 1 as compared to the greater losses experienced in trial 4 on clover hay. Any residual effect of the previous feeding of

minerals as mentioned before would be a factor that might have tended to produce the results obtained.

As to the possible influence of sunlight in these experiments little can be said. No record was kept of the actual number of hours of exposure but at the most it could not have exceeded thirty hours in any of the combined preliminary, transition and collection periods. From a survey of the sunlight records of the local weather bureau it can be assumed that any possible influence of sunlight was fairly uniform in all of the trials. Since in these experiments from this standpoint the treatment approached that used in general practice, under similar weather conditions it could be said that the effect of sunlight was not sufficient to counterbalance the deficiency in the rations of the factor affecting calcium assimilation. Further work should determine what would be the influence of sunlight under summer conditions. From work with swine by Maynard and co-workers (15) little difference was noted between winter and summer sunlight conditions in the prevention of stiffness in swine. Just what may constitute an adequate amount of sunlight to induce calcium assimilation in dairy cattle should be determined.

The question of the accompanying protein metabolism on mineral assimilation is one which has not been investigated thoroughly and may be considered in the interpretation of the results obtained in this work. Monroe (11) has noted negative calcium balances on wide rations and positive balances on narrow rations, the narrow rations containing a higher percentage of freshly cured clover hay. Numerous investigators have demonstrated the superiority for mineral assimilation of certain roughages over others which are known to contain less protein which is thought to be of inferior quality. With swine, certain protein supplements seem to be superior to others in their effect on mineral asssimilation. Maynard and co-workers (16) working with swine have noted the beneficial effects of fish meal on mineral assimilation where a constant plane of protein intake was maintained. In many mineral studies the ingredient of the ration which is being studied carries not only an increased supply of minerals and perhaps the factor aiding their assimilation but also

more protein of a better quality. It may be logical to attribute the beneficial effects on mineral nutrition to the minerals added or their aided assimilation, however, though it may be only a coincidence, the fact remains that increased mineral assimilation has been accompanied by either or both an increase in the amount of or an improvement in the quality of protein.

In this work a better assimilation of calcium occurred under conditions where protein of supposedly superior quality was used while a constant plane of intake was maintained. In the work of Monroe the plane of protein intake was raised by the substitution of protein of superior quality. It would seem that the quality of protein may be an important factor in the interpretation of the results of studies of mineral metabolism and as such it is offered in this work. A report of the nitrogen balance studies carried on in connection with this work will throw more light on the accompanying protein metabolism.

Phosphorus balances

The phosphorus balances are all negative except in the case of cow 3 in trials 1 and 2. This animal was the highest producer and the heaviest cow used in the experiments and as such required more of a higher protein grain mixture in combination with a fixed amount of silage and hay. From the phosphorus balances resulting is indicated an increased assimilation of phosphorus corresponding with a higher intake than that of the other cows. Accompanying this condition were negative calcium balances. Such independence of calcium and phosphorus assimilation has been noted at various times by several workers. It is further brought out in an examination of the remaining balances obtained in this work. The explanation for such a storage as seen in the case of cow 3 is difficult. There is perhaps little possibility of a longstanding condition of this kind but again it may be, in this case, the result of a previous condition where this cow was not receiving phosphorus enough to cover her requirements. More flexibility in the mobilization of phosphorus is possible than in the case of calcium, due to the higher content of phosphorus in the softer tissues of the body in addition to that contained in the bones.

In addition, in three other cases, the phosphorus balances although negative indicate increased utilization of phosphorus when its content in the grain mixture was increased. As in the case of cow 3 it might be possible for a cow to be in a negative calcium balance and phosphorus equilibrium at the same time. Such a possibility has been pointed out by Meigs (8).

Hart and co-workers (2) have observed that the quality of the hay not only affects the assimilation of calcium but also that of phosphorus. With an increased assimilation of calcium in such a case we might also expect an increased assimilation of phosphorus. The balances determined in this work are not generally in agreement with such a statement but may be similar to those

TABLE 5

Calcium and phosphorus content of milk

COW NUMBER	TRIAL 1		TRIAL 2	
	Ca	P	Ca	P
	per cent	*per cent*	*per cent*	*per cent*
1	0.1126	0.0864	0.1194	0.1021
2	0.1134	0.0852	0.1236	0.0955
3	0.0926	0.0894	0.1077	0.1008
	TRIAL 3		TRIAL 4	
4	0.1159	0.1022	0.1149	0.0878
5	0.1021	0.1020	0.1014	0.0926
6	0.1152	0.1034	0.1121	0.0976

obtained later by Hart (5) when due to a generous provision of wheat bran in the ration positive phosphorus balances accompanied calcium losses on green grass. It is therefore of practical interest that the phosphorus demands of dairy cattle can be provided for by adequate grain mixtures although it is questionable whether or not this is actually achieved in practice.

The calcium and phosphorus content of the milk is given in table 5. An inspection of these data indicates that the concentration of these elements in milk is fairly constant. A comparison of the composition of the milk from the same cow in the different trials shows in all cases a slightly higher calcium content when the cows received timothy hay instead of clover hay.

Greater differences are noted in the same direction in all instances in the case of phosphorus. To be sure, the differences observed are small but they are fairly uniform and if significant they bear out the previously mentioned contention of an increased assimilation of phosphorus in response to the increased supply of this element in trials 2 and 3 over that of trials 1 and 2.

There is a popular belief that the mineral content of cows' milk is altered in response to an increased mineral assimilation. From table 5 it can be seen that any variation that may have occurred in this case is very small and was probably the result of an increased mobilization of phosphorus rather than of calcium.

SUMMARY

1. The results of twelve determinations of the balances of intake against outgo of calcium and phosphorus with liberally milking dairy cows are given.

2. A better assimilation of calcium resulted when clover hay instead of timothy was fed as part of a ration which included corn silage and a grain mixture.

3. A better assimilation of calcium occurred under conditions where protein of supposedly higher quality was fed through the medium of clover hay.

4. Some independence between calcium and phosphorus assimilation was observed.

5. Better assimilation of phosphorus occurred when more ample provision was made for this element in the grain mixture.

6. There was but little variation in the calcium and phosphorus content of the milk under the conditions studied. The percentage of phosphorus in the milk seemed to increase slightly in response to an increased supply in the feed.

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ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The twentieth annual meeting of the American Dairy Science Association was held in connection with the National Dairy Exposition at Indianapolis, Indiana, on October 12 and 13, 1925.

The first general session which convened at the Hotel Severin at 9:00 a.m. October 12 was called to order by President O. E. Reed who spoke briefly of the work of the Association. The minutes of the 1924 meeting were read and approved. The report of the secretary-treasurer, J. B. Fitch, was read and adopted.

Divisional meetings were reported on by:

A. A. Borland for eastern division.

C. A. Hutton for southern division.

F. W. Atkeson read a report submitted by H. A. Bendixen for the western division.

C. H. Eckles reported on the Union of Biological Societies. He outlined the plans of the Union and stated that Rockefeller Foundation has $350,000 to be spent in ten years for the publication of abstracts. This would be available January 1, 1926.

C. H. Eckles also reported as representative to the National Research Council.

At the request of W. E. Skinner, the President appointed a committee to study the Dairy Exposition and to make suggestions for improvement. The following committee was appointed: W. A. Stocking, F. W. Atkeson, H. H. Kildee, and E. M. Harmon.

The President also appointed the following members of the National Research Council Advisory Committee:

A. A. Borland and R. S. Breed their terms expiring July 31, 1926.

H. A. Ruehe and W. M. Regan whose terms expire July 31, 1927.

O. F. Hunziker and L. A. Rogers whose terms expire July 31, 1928.

The representative to the National Research Council is to act as chairman.

H. P. Davis spoke briefly on the advisability of appointing a committee to study the courses in dairying offered at the different institutions with the idea of unifying and making more standard the courses offered. No action was taken on this suggestion.

J. H. Frandsen spoke regarding the JOURNAL OF DAIRY SCIENCE, outlining future plans for that publication.

C. H. Eckles suggested that the allowance of $300 for the editor of the Journal of Dairy Science was inadequate and warranted an increase more in keeping with the experience and duties of that position. President Reed appointed a committee composed of Eckles, Larson and Stocking to study and make recommendations.

The following nominations for 1926 were reported by A. A. Borland, chairman of the nominating committee:

For President: O. E. Reed, Michigan; J. M. Fuller, New Hampshire.

Vice-President: H. F. Judkins, Massachusetts; A. C. Baer, Oklahoma.

Secretary-Treasurer: G. C. White, Connecticut; H. A. Ruehe, Illinois.

Editor: J. H. Frandsen, Nebraska; A. C. Dahlberg, New York.

The final selection is to be made by mail ballot as provided in the constitution.

Announcements were made concerning the meeting for the next day and concerning the banquet. The meeting adjourned at noon, to convene again October 13, after the sectional meetings.

SECOND SESSION, TUESDAY OCTOBER 13, 1925, 9:00 A.M.

After the meetings of the different sections a general session was called for Tuesday, October 13, 1925. J. A. Gamble reported on the Production Section, H. F. Judkins for the Manufacturing Section, L. W. Morley for the Extension Section and C. E. Wiley for the Advanced Registry Section.

A. A. Borland spoke briefly on the uniform cow testing associa-

tion rules adopted by the Extension Section. It was his idea that they were very much the same as the proposed Ayrshire herd test. Ragsdale, Morley and Baltzer also spoke regarding the uniform rules.

C. H. Eckles submitted the following report from the committee appointed to study the allowance for the Editor of the JOURNAL:

"The committee recommends to the Executive Committee that the sum of $300 be added to the budget for the Editor's office the payment of this additional sum to be contingent upon an equal sum being brought into the hands of the Treasurer as a result of the proposed membership campaign."

It was the idea of the meeting that no increase could be made unless the membership was increased. With this in mind all agreed to help the Secretary in increasing the membership. Mortensen, Borland, Hayden and Stocking spoke regarding the membership of the Association.

The following budget for 1926 was submitted as approved by the Executive Committee:

Editor's allowance	$300
Secretary's salary	100
Secretary's office	100
Three divisions	75
	$575

The following officers were elected in the different sectional meetings:

Section I Production:
C. C. Hayden, Chairman
O. G. Schaefer, Secretary

Section II Manufacturing:
A. C. Baer, Chairman
C. D. Dahle, Secretary

Section III Extension:
A. J. Cramer, Chairman
C. F. Finley, Vice-Chairman
C. R. Gearhart, Secretary

Section IV Advanced Registry:
C. E. Wylie, Chairman
W. E. Petersen, Secretary

C. H. Eckles reported for the committee on the revision of the constitution.

The annual banquet was held at the Hotel Severin at 6:30 Tuesday evening, October 13. H. F. Judkins acted as toastmaster and A. J. Glover, editor of Hoard's Dairyman was the principal speaker.

Announcements were made of awards and presentation of prizes in Intercollegiate Judging Contests. Mr. Wm. White presented the awards to winners in Dairy Products and Mr. W. W. Swett, to winners in the Dairy Cattle Contest.

J. B. FITCH,
Secretary.

PRODUCTION SECTION

The Production Section of the American Dairy Science Association was called to order by Professor J. A. Gamble, Chairman. Secretary J. P. LaMaster being absent, Professor A. C. Ragsdale acted as secretary.

The minutes of the last meeting were read and approved.

Professor H. E. Van Norman, representing the National Dairy Association gave an address dealing particularly with the Farmers Judging Contest and placing card. This placing card had been recommended to the National Dairy Association and adopted for use this year by a committee appointed the previous year by this section of the American Dairy Science Association. This committee reported as follows:

Your Committee on Dairy Cattle Placing Card for Farmers Judging Contest submits the following report:

Several informal meetings of the Committee were held with three of the four members present—not always the same ones.

Taking the placing card devised by the Animal Husbandry Department of the University of Wisconsin, and used at the last National Dairy Show, as a starting point, the accompanying placing card was approved by the Committee and recommended to the National Dairy Show for use this year, which recommendation has been accepted.

The card was printed as per copies attached herewith and samples mailed by the National Dairy Association to 77 dairy department professors in 35 states. National Dairy Association offered to supply any desired number at cost. Nine professors secured for trial, copies in varying numbers from a few to several hundred, while Wisconsin printed ten thousand just like this.

Inquiries as to the working out of this score card in practice were directed to the professors who secured additional copies for use. Seven replied unanimously approving the placing card arrangement as submitted herewith. One instructor did raise the question as to whether the final placing should not count more than 50 per cent of the total score, which question the Committee does not attempt to answer, as the 50–50 basis is used in the National Students Judging Contest and other similar contests.

Referring to the key for scoring the contestants, four instructors reported using this key, one without modification and three modifying the values to fit the classes being judged.

One department which has not used the card suggests omitting the key from the card, while Professor Humphrey, who has had the largest experience in the use of this card, would supply a complete key with all possible combinations shown with their values. This would require 24 tables like the one printed on the reverse of this card.

Your Committee recommends that the American Dairy Science Association receive this report, give such publicity to the placing card herewith submitted as circumstances may permit; further, that the Committee continue to collect further data concerning the use of this card and report at the next annual meeting such suggestions for improvements or modifications as circumstances may dictate; and further that the Association authorize the printing of the following phrase on these placing cards:

Placing Card Recommended by the American Dairy Science Association

Report respectfully submitted,

SPECIAL COMMITTEE ON FARMERS JUDGING PLACING CARD,
J. C. HUMPHREY
H. H. KILDEE
W. W. SWETT
H. E. VAN NORMAN, *Chairman.*

The report of this special committee on the Farmers Judging Placing Card was accepted, placed on file and the committee continued.

W. W. Swett, Chairman of the Committee on the Students Dairy Cattle Judging Contest, gave the following report:

The annual meeting of the committee on the Students Dairy Cattle Judging Contests was held at the office of the National Dairy Association, Chicago, Illinois, March 21st, 1925. The meeting was called to order by the Chairman. The following members of the Committee were present: A. A. Borland, L. H. Fairchild, H. H. Kildee, W. W. Swett; and also H. E. Van Norman and S. H. Anderson of the National Dairy Association.

The material presented to the Committee by the chairman consisted of suggestions received relative to methods of improving the conduct of the contest work. These suggestions were read over and carefully considered.

Only one outstanding change in the rules was made at this annual meeting. This change provides that the superintendent shall select a judging committee, composed of two judges, preferably college men or ex-college men of recognized ability on all four breeds, to act with a special breed judge for each breed. It was the sense and understanding of the committee that the special breed judge shall have the qualifications and duties of the associate judge of 1924, that he shall have equal voice with the two other members of the committee in placing the rings of the particular breed on which he is working and that the committee shall decide on one placing for each class by working together rather than independently. This decision was reached after a lengthy discussion by each of the members of the committee which revealed within the committee a very strong sentiment for developing the contest on a basis in which the college view point would predominate.

A short time after the annual spring meeting a circular letter signed by the coaches of 24 different state institutions came to the Chairman unsolicited. This circular letter made a number of specific suggestions and recommendations for changes in the rules governing the contest. The changes made at the meeting were, in all essentials, directly in accord with those written requests from 24 different states.

A number of other minor changes in the wording were necessary to make the rules conform to the one major change outlined. The question of the relative merits of oral and written reasons was discussed thoroughly but no change was made in this regard.

Preliminary arrangements were outlined for the annual banquet of the American Dairy Science Association. The responsibility for this banquet was placed on Professor Borland.

The question of some kind of a score card for simplifying the contest procedure was discussed, but no action was taken.

The rules as amended were unanimously adopted as a whole.

The meeting adjourned at 5:00 p.m.

A. A. BORLAND,
L. H. FAIRCHILD,
J. B. FITCH,
J. M. FULLER,
L. W. INGHAM,
H. H. KILDEE,
W. M. REGAN,
W. W. SWETT, *Chairman.*

This report was approved and placed on file.

Dr. Sewell Wright, of the United States Department of Agriculture gave a most excellent address on *Inbreeding and Crossbreeding.*

R. R. Graves, of the United States Department of Agriculture, gave an address on Breeding Dairy Cattle for High Milk Production. This address together with that of Dr. Wright, occasioned some little comment and were much appreciated.

The report of the nominating committee was unanimously approved and C. C. Hayden, Ohio, and O. G. Schafer, Minnesota, were declared elected president and secretary respectively of Section I.

The meeting adjourned at 4:15 p.m.

A. C. RAGSDALE,
Acting Secretary.

MANUFACTURING SECTION

The Dairy Manufacturers' Section of the American Dairy Science Association was called to order by Chairman, H. F. Judkins on October 12, 1925 at the Hotel Severin at Indianapolis, Ind.

The minutes were read by Secretary N. E. Olson and approved.

Professor Judkins reported for the Committee on Judging

Dairy Products. This report recommended the inclusion of ice cream in the next year's contest.

The report which follows was adopted as read:

Report of Rules Committee for the Students Dairy Products Judging Contest at the National Dairy Show, October 12, 1925

Rule 13 now reads, "Each contestant shall score and criticize ten tubs of butter, ten cheeses, and ten samples of milk, the time allowance being one hour for each product." It is recommended that the following be added, "A five minute rest period shall be allowed at the end of each one hour judging period."

The last part of Rule 16 reads, "The contestants shall have access to these samples, five minutes for each product, just previous to the scoring of the contest samples. To make it clearly understood that the contestants cannot refer to these samples while the judging of the contest samples is in progress the words, "and then only," should be added. It is recommended that the time for examination of these samples be changed to ten minutes.

It is recommended that the rules committee be left with power to decide whether ice cream shall be included in the contest next year with the understanding that they will be guided by the judgment of the coaches who participate in the practice judging tomorrow. If ice cream is included next year it is recommended that the number of samples of each product be changed from ten to seven and the time for judging each product changed from one hour to forty-five minutes.

The first paragraph under judges, page eight, reads, "The superintendent of the contest shall select a committee of two judges to judge each product and shall, as far in advance of the contest as possible, notify each institution as to the personnel of these committees."

It is recommended that the last part of the sentence relative to notifying the colleges as to the personnel of the judges be omitted.

Score cards

In arranging the defects under "bottle and cap" on the milk score card the bottle defects should be arranged separately from the cap defects. It should be made clear just what score is given to the different types of caps. It is recommended that if ice cream is judged next year that on the student's score card the defects be stated as on the score cards for other products, that is, not grouped under a definite range of score as they are now.

The committee is always open to suggestions as to how to secure more prizes and as to what the nature of these prizes should be.

Respectfully submitted,

M. MORTENSEN,
H. W. GREGORY,
G. D. TURNBOW,
W. H. WHITE,
H. F. JUDKINS,
Rules Committee.

NOTE: No further action was taken at the meeting in regard to including ice cream in next year's contest than that stated in committee's report.

Dr. R. S. Breed reported for the Committee on Bacteriological Methods. The report was approved and the committee continued. It was suggested that a sub-committee for bacteriological methods for ice cream be appointed. The suggestion was approved by vote and Chairman Judkins appointed, A. C. Fay, F. W. Fabian, and B. W. Hammer. Motion that this committee be instructed to act with a committee appointed by the National Association of Ice Cream Manufacturers, carried. Professor Judkins appointed himself a committee of one to present the matter to the ice cream men's convention at Detroit.

Dr. Harding suggested a separate score card for pasteurized milk. Professor Fisher moved that the suggestion be referred to the score card committee. Carried.

Mr. R. C. Potts reported for the Committee on Economic Phases of the Dairy Industry. Report approved.

Professor C. L. Roadhouse presented a report on "Judging Dairy Products in Our High Schools." An interesting motion picture of the activities of the dairy depart nent, at Davis, California, was also exhibited.

O. R. Overman, Urbana, Ill., presented a paper on "The Relation of Solids in Milk to Fat and Specific Gravity of the Milk." Ordered placed on file.

R. C. Fisher, Cincinnati, Ohio, reported at length for the Committee on Testing Ice Cream for Fats and Solids. The report was ordered placed on file and the committee continued. It was suggested by A. C. Dahlberg that a central committee on Chemi-

cal Methods of Testing Dairy Products be appointed. Moved by R. C. Fisher that such committee be appointed to be composed of the chairman of the other committees on Testing Dairy Products. Motion carried and the following committee appointed, O. F. Hunziker, Chairman, R. C. Fisher, H. C. Troy, and A. C. Dahlberg.

Dr. Otto Rahn of Kiel, Germany, next delivered an interesting report on the Dairy Physics Department of the Government Dairy School in Kiel.

A number of interesting reports of research work included the following:

"Federal State Butter Inspection as a Means for Quality Improvement." C. W. Fryhofer, St. Paul, Minn.

"Correlation of the Scored Butter and Its Methods of Manufacture on Yeasts and Molds in Butter." E. A. Parfitt, Lafayette, Ind.

"The Effect of Ice Cream Ingredients Upon the Viscosity of the Mix." D. A. Downs, Lincoln, Nebr.

Professor P. M. Brandt delivered a thorough report on "The Operation of College Creameries."

Professor A. C. Baer was called upon to tell of the successful operation of a coöperative creamery in conjunction with the College at Stillwater, Oklahoma. The report was approved.

Professor Roadhouse then suggested that a committee be appointed to present the above report to the National Dairy Organizations such as The National Milk Dealers' Association, The Ice Cream Manufacturers Association, The American Association of Creamery Butter Manufacturers, The National Buttermakers' Association, and the National Cheese Association.

The suggestion was approved and Chairman Judkins appointed the following committee: C. L. Roadhouse, Chairman, O. F. Hunziker and P. M. Brant.

Election of officers of Section II resulted as follows: A. C. Baer, Stillwater, Okla., Chairman; C. D. Dahle, State College, Penn., Secretary.

The meeting adjourned at 6:15 p.m. until 1926.

N. E. Olson,
Retiring Secretary.

EXTENSION SECTION

The Extension Section this year held one of the most interesting meetings in its history. About 70 members were present from 18 states and the District of Columbia. The committee reports showed that much work had been done by the various committees, and splendid papers were read on subjects of timely interest.

The meeting was called to order by the Chairman, L. W. Morley. Minutes of the last meeting were read by the Secretary, C. A. Hutton, and approved.

Reports of the various committees were called for. Professor J. D. Brew, Chairman of the Dairy Manufacturing Committee, was absent.

Professor E. B. Fitts, Chairman of the Feeding Committee, submitted a written report together with copies for each member of the Extension Section. Professor Fitts emphasized the importance of practical suggestions in bulletins and other printed material, as well as in talks to demonstrators about feeding methods and rations. He referred to a number of useful bulletins which have been issued by various dairy specialists during the year. He also called attention to the value of the feeding school, conducted in the demonstrator's barn, as a useful method of interesting the dairymen in the community in improved rations.

Miss Jessie M. Hoover, Chairman of the Milk Campaign Committee, said she would submit a mimeographed report for members.

Mr. L. A. Higgins, Chairman of the Bull Association Committee, was not present, and the report was read by the Secretary and adopted by the meeting.

An interesting discussion followed and a motion was adopted that the work of the committee be broadened to include dairy sire work in general.

Mr. E. J. Perry, Chairman of the Calf Club Committee, submitted a written report which was read and adopted. The recommendations of this committee were as follows:

1. That high average results per member rather than a large enrollment should be the goal.

2. That membership should first be enlisted from among those responsible families most in need of good dairy animals.
3. That subject matter for use by calf clubs should be prepared by the extension specialists in consultation with the dairy department.
4. That a manual or bulletin containing in simple form the fundamentals of management be used, supplemented with seasonal circular letters.

   Circular letters may well contain questions to be answered by the members from reference bulletins, manuals, etc., the answers to be returned to the club leader or specialist.
5. It is strongly urged that in follow-up work every effort be put forth by club leaders and dairy extension workers to secure yearly records on all milking heifers.
6. That the records of milking animals be summarized, first by the various states and then nationally. These records while privately made should be used in contrast with the United States average production per cow to strengthen the calf club work throughout the country.

Mr. A. B. Baltzer, Chairman of the Cow Testing Association Committee, submitted a lengthy and very interesting written report. A very interesting discussion followed. A motion was carried that the report be adopted and presented to general session of American Dairy Science Association. This report showed that the committee had given a great deal of time and thought to the task of working out a system for uniform methods of cow testing association work throughout the various states. The report covered standard rules and regulations for the operation of testing associations. It was later presented to the general session of the American Dairy Science Association, where it was unanimously adopted.

"Methods of Dairy Extension and Follow-up Work" was the subject of a paper by Mr. E. J. Perry. Mr. Perry brought out some interesting points in regard to new methods of systematic planning of extension work.

Mr. J. B. Parker gave a report on short-cut methods in cow test association work. He emphasized sticking to the regular cow-test association plan wherever possible.

The following officers were elected: Chairman, A. J. Cramer, Wisconsin; Vice-Chairman, C. B. Finley, Iowa; Secretary, C. R. Gearhart, Pennsylvania.

Chairman Morley announced that a new plan was being introduced this year, whereby the members of the Extension Section will be furnished copies of the various papers and committee reports.

Adjournment.

NOTE: Copies of the committee reports and papers have been sent to the members of the Extension Section. Any member failing to receive copies, or desiring additional copies, should communicate with Mr. C. R. Gearhart, Secretary, State College, Pa.

C. A. HUTTON,
Secretary.

ADVANCED REGISTRY SECTION

Meeting of the Advanced Registry Section of the American Dairy Science Association, Monday, October 12, 1925, at the Severin Hotel, Indianapolis, Indiana.

In the absence of Professor G. C. White of Connecticut, the section elected C. E. Wylie of Tennessee to act as Chairman. M. H. Campbell of Illinois was appointed as Acting Secretary. C. E. Wylie, as Secretary, read a report of the minutes of the last meeting at Milwaukee. Mr. Harris of Wisconsin gave the following report for the Investigation Committee.

Conclusions of Investigation Committee

It would seem that sufficient data has been presented to warrant the conclusion that the one-day test, at least under normal conditions, is about as reliable as the one for two days. Three independent studies show very close agreement in results and larger numbers would evidently reduce the variation still further. It is therefore pertinent to consider what, if any, abnormal conditions might affect the reliability of the one-day test to a greater extent than would obtain in a test for a longer period.

Experiments to determine the effects of various feeds indicate that such effect is, generally speaking, not immediate and usually not apparent until the second day. Darnell of Texas is continuing this in-

vestigation, preliminary results being in accord with the above. If this be true, the shorter period is an advantage. There is room for further investigation along this line and also to determine the effect of lengthening or shortening the interval between milkings, changing method of milking and feeding or not feeding cows while being milked.

Professor Colman, Oregon, submitted a report entitled "A Study of the Estimated Versus the Actual Milk Weights as Reported by the Breeders" which is not included in the body of this report only because of lack of space.

Respectfully submitted,

ROY T. HARRIS, *Chairman,*
Committee on Investigations.

Mr. Harris' report was accepted.

Mr. Musser of the American Guernsey Cattle Club, brought up a question requiring the supervisor not to talk during a test. It was moved and seconded and passed that this be referred back to the Breeds' Relation Committee.

Professor Conklin of the Ayrshire Breeders' Association presented the plan of the Ayrshire herd test. He stated that this plan was presented to the committee for their suggestions and criticisms, in as much as it was the plan of this test to have the Advanced Registry Officials in the several states to supervise the herd test system.

Ayrshire Herd Test Plan

1. The Test shall be available to Ayrshire herds, grade and purebred.
2. When a herd is entered in the Test every cow which has ever freshened or freshens subsequently shall be included without reference to period of lactation.
3. All cows must be identified by tattooing.
4. Cows shall not be milked more than twice per day, except when producing as much as the following quantities: mature cows, 40 pounds, four year olds, 35 pounds; three year olds, 30 pounds, and two year olds, 25 pounds.
5. The Test shall be for a period of twelve months and breeders are urged to enter their herds with the intention of continuing them in the Test year after year.
6. The Test shall be based upon a one day inspection of milk and fat

production each month with such additional surprise tests as may be deemed necessary for authentication. It is strongly recommended that daily milk weights be kept by the owner to indicate the exact milk production. Lacking daily records, the month's credit for milk shall be computed from the day's production.

7. A maximum of 20 cows may be included in one day's test when none are milked more than twice per day. In no case shall the test include more than forty milkings per day.

8. No minimum qualifying production requirements for herd averages shall be set. In calculating herd averages the production of all cows which have ever freshened and are owned in the herd eight months or more of the year shall be counted.

9. Supervision and authentication of Herd Tests in the several States shall be under the direction of the Agricultural Colleges. Cow testing association supervisors may conduct the tests provided the requirements of the Ayrshire Breeders' Association and the supervising College are met, it being understood in such an instance that the supervisor while engaged in the work of the Herd Test is considered the employee and representative of the college and responsible to it. Payment for his work shall be made by the College, fees being paid the College by the herd owner. Where no cow testing association is available supervision may be made by the men employed by the College in official and semi-official testing or by such other qualified agencies as may be agreed upon by the Ayrshire Breeders' Association and the College.

10. To enable owners of herds entered in this test to secure the extra authentication and publicity of Roll of Honor records on outstanding individuals it is provided that semi-official tests may be conducted in connection with the Herd Test, provided the requirements of this test and of Article III of the By-Laws are met.

11. A herd test book shall be furnished by the Ayrshire Breeders' Association to each owner whose herd completes a year's test. This shall be arranged to provide a separate page for each cow on which is given for each month the production of milk during the day of the test, the fat percentage, amount of milk and fat for the month, the value of the product, the amount and cost of feed, and the profit or loss. In the back there shall be space for a summary of the year's work of each cow tested and for the seal of the Ayrshire Breeders' Association.

12. Upon receipt of information that a breeder desires to enter his herd in this test the Ayrshire Breeders' Association shall mail a blank

which the applicant shall fill out and forward to the Ayrshire Breeders' Association together with fees to cover the Association's charge for the first month. Provision shall be made on this blank for an application for test which shall incorporate a certification that the data submitted on the herd is accurate and that the applicant will endeavor to see that the test data collected accurately measures the production of the herd. The following information shall be given for all cows in the herd which have ever freshened, Registry number if recorded, tattoo marks, age, date of last calving, service dates, etc.

Upon acceptance of an application for a herd test the Association shall make arrangements for the beginning of the monthly supervisions. Monthly records shall be sent to the Ayrshire Breeders' Association and entered there in the herd test book. Carbon copies shall be left on the farm. At the end of the year the book shall be summarized by the Ayrshire Breeders' Association and sent to the herd owner as a permanent record of his herd's performance.

13. Individual herd test certificates. Certificates of individual records of meritorious cows in the herd test shall be furnished when such cows produce as much as the following quantities of milk and fat specified during the 305 days of the test and drop living calves within 400 days of the previous freshening and such records are accepted by the Ayrshire Breeders' Association:

	MINIMUM REQUIREMENTS	
	Milk	Fat
	pounds	*pounds*
Mature	7,500	300
Senior Four	7,000	280
Junior Four	6,600	264
Senior Three	6,150	246
Junior Three	5,700	228
Senior Two	5,250	210
Junior Two	4,800	192

14. Sires with four daughters out of four different dams, qualifying for Herd Test Certificates, shall be designated as Herd Test Sires, and each assigned a number.

15. Fees. Charges for tests shall be borne by owner, including surprise tests and any special tests for authentication which may be deemed necessary by the Ayrshire Breeders' Association or the Agricultural College.

A fee of twenty cents per month per cow in milk shall be charged by the Ayrshire Breeders' Association for computing the records, publication of accepted records, blanks, herd books, etc. This fee shall be payable in advance.

The first part of the committee meeting was devoted entirely and at some length to a discussion of this plan of testing. Those present thought that the principles of this test were of far reaching importance to the conduct of Advanced Registry Testing and therefore this subject was the most important subject to be considered at this meeting. This plan of testing includes the testing of all cows in Ayrshire herds both grade and purebred. It provides for a one-day test, as many as twenty cows on test in a day, one or more cows milked at a time, cow testing association or Advanced Registry Testers and authentication of the test reports by the colleges. Conklin, Reed and Campbell expressed the idea that there was a tendency for this kind of testing to increase. Regan, Fitch and Wing thought that this idea was a compromise between Advanced Registry Testing and Cow Testing Association Records. Everyone seemed to agree that the rules for Advanced Registry Testing should not be materially lowered as they were the outgrowth of many years of constant revision. At the same time everyone seemed to think that the herd test plan was a good thing to encourage.

It was moved and passed that the Breeds' Relation Committee approve the conducting of the herd test by the Supervisor of Advanced Registry of the various states so long as the rules of the American Dairy Science Association governing official testing are followed. A motion was passed favoring the appointment of one man from the Breeds' Relation Committee to consider with a man appointed from the Investigation Committee, the herd test plan.

Regan of California presented a plan for uniform guarantee for payment of Advanced Registry Testing. This report which follows was adopted:

Report of Sub-Committee on Uniform Guarantee in Payment Testing Accounts

Resolved, That we of the Testing Section of the American Dairy Science Association, feeling keenly the need for a more definite and uniform practice as regards guarantee of testing accounts by the various cattle clubs, do recommend the following as the preferred practice in handling such accounts.

1. That the college concerned render bill to the owner for tests conducted as promptly as possible after the work is completed.

2. If bills rendered for as much as two months work be not paid by the time the statement for the third month is ready, such statement should be made out listing items in full with dates of service rendered and presented to the cattle club concerned.

3. If such statement covering three months testing is not paid by the owner within 15 days following the date of rendering such bill to the cattle club the college notify the owner that he is delinquent and that testing in his herd is and has been suspended until such time as his account shall be paid.

4. If the delinquent breeder fails to make payment within 15 days following the date when he is declared delinquent, the college is to render final detailed statement to the cattle club (no further tests being conducted in the meantime) and the cattle club to make payment to the college within 30 days or as soon as items can be properly verified.

Be it further resolved that the Chairman of the Breeds' Relation Committee be instructed to transmit these resolutions to the proper official of the respective breed associations requesting their adoption by them and their incorporation in the breed handbooks and literature on official testing.

R. T. HARRIS,
W. M. REGAN.

It was brought to the attention of this committee that a rule should be made to prohibit the talking of test supervisors or in otherwise interfering with a cow where he is supervising the testing. There was also a discussion in regard to a rule governing the adulteration of sulfuric acid. No motion was passed concerning these two points but it was thought best to properly instruct the supervisor on these two subjects.

A motion was passed that Advanced Registry Section favor

either a one-day test with preliminary milking or a two-day test with preliminary milking in the conduct of Advanced Registry Testing.

Signed: C. E. WYLIE, *Chairman*,
M. H. CAMPBELL,
J. B. FITCH,
O. E. REED,
J. R. DICE.

Following the Report of the Breeds' Relation Committee Professor Regan asked for a discussion regarding the Ayrshire herd test plan. Professor Conklin of the Ayrshire Breeders' Association presented this plan to the meeting. There was considerable discussion on many phases of this plan. It was moved, seconded and passed to amend the Breeds' Relation Report as follows:

That the supervision of a herd test plan follow in a general way, the rules as proposed by the Ayrshire herd test plan and that differences between this and the Advanced Registry rules be adjusted by a sub-committee of the Breeds' Relation Committee, such committee to work with the Ayrshire Breeders' Association and other associations during the year and to come before this section with certain recommendations next year. The report of the committee as amended was approved unanimously.

Professor Conklin of the Ayrshire Breeders' Association proposed a College Students' Essay Contest on the Economical Value of Production Tests. It was moved and passed that this plan be referred to the general session and that a man be appointed to represent the American Dairy Science Association on the Contest Committee.

In the absence of W. E. Peterson of Minnesota, Mr. Harris of Wisconsin read a paper prepared by Mr. Peterson on "The Adulteration of Sulfuric Acid Used in Testing for Advanced Registry." This paper was summarized as follows:

1. Most fats and oils added to the sulfuric acid will increase the test of milk when such acid is used. All such fats and oils float on top of the acid and cause it to become very dark and sirupy, but do not affect its activity.

2. Many fat solvents when added to sulfuric acid will increase the test of milk where such acid is used. All float on top of the acid, but many do not affect the appearance of the acid nor its activity. Duplicate samples of milk where such acid is used will fail to check within permissible limits.

3. Saturated solutions of butterfat in gasoline, benzine and xylol will not materially affect the appearance of cold acid and will remain in solution with the acid for an hour or more after becoming thoroughly mixed. Successive samples of acid drawn will produce identical results; all samples checking in duplicate within the permissible limits of variation.

4. The presence of any substance in the sulfuric acid that will increase the test of milk when such acid is used in testing can be detected by making a "blank" test of the acid.

Mr. Davidson of Illinois presented a paper on "The Methods of Detecting the Leaving of Milk in the Cow's Udder." Mr. Johnson of Connecticut Agricultural College, gave a report of "The Study of the Padding of Milk Weights."

On ballot C. E. Wylie was elected Chairman, W. E. Peterson Secretary of Section IV, for 1926.

The meeting adjourned.

C. ELMER WYLIE, *Secretary,*
per M. H. Campbell.

REPORT OF THE NINTH STUDENTS NATIONAL CONTEST IN JUDGING DAIRY PRODUCTS

Held at Indianapolis, Indiana, October 12, 1925

The personnel of the official judging committees was as follows:

For Butter:

O. S. Hagen, Bureau of Agricultural Economics, U. S. Department of Agriculture.

C. L. Pier, Bureau of Agricultural Economics, U. S. Department of Agriculture.

For Cheese:

C. W. Fryhofer, Bureau of Agricultural Economics, U. S. Department of Agriculture.

For Milk:

R. J. Posson, Bureau of Dairying, U. S. Department of Agriculture.

C. J. Babcock, Bureau of Dairying, U. S. Department of Agriculture.

The trophies offered in this contest and the winners of these trophies this year are as follows:

National Dairy Exposition cup for team highest in all products Iowa State College.

J. G. Cherry cup for team highest in butter. South Dakota State College.

Hoard's Dairyman cup for team highest in cheese. Iowa State College.

J. B. Ford cup for team highest in milk. West Virginia University.

National Federation of Milk Producers cup to institution having highest individual in milk. W. B. S. Woodward, Ohio State University.

Gold medal for highest individual in judging all products, given by National Dairy Exposition. W. W. Richman, Pennsylvania State College.

Silver medal for second highest individual in judging all products, given by National Dairy Exposition. Snowden R. Clary, Iowa State College.

Bronze medal for third highest individual in judging all products, given by National Dairy Exposition. Walter L. Olson, Iowa State College.

Gold medal for highest individual in butter. American Creamery Butter Mfgrs. Association. Walter L. Olson, Iowa State College.

Silver medal for second highest individual in butter. National Dairy Exposition. Emery Bartle, South Dakota State College.

Bronze medal for third highest individual in butter. National Dairy Exposition. Daniel Jacobsen, South Dakota State College.

Gold medal for highest individual in cheese. National Cheese Association. Snowden R. Clary, Iowa State College.

Silver medal for second highest individual in cheese. National Dairy Exposition. Ralph P. Wilson, Iowa State College.

Bronze medal for third highest in cheese. National Dairy Exposition. W. W. Richman, Pennsylvania State College.

Gold medal for highest individual in milk. International Milk Dealers Association. W. B. S. Woodward, Ohio State University.

Silver medal for second highest individual in milk. National Dairy Exposition. Geo. N. Gray, Oregon Agricultural College.

Bronze medal for third highest individual in milk. National Dairy Exposition. L. L. Lough, West Virginia University.

REPORT OF THE SEVENTEENTH STUDENTS DAIRY CATTLE JUDGING CONTEST INDIANAPOLIS, INDIANA, OCTOBER 10, 1925

Twenty-four teams were entered in this contest, twenty of which are listed in the table showing the standing in all breeds.

Individuals

Ayrshires (no prize)

Name	*State*	*Score*
1. W. N. Wehr	Ohio	378
2. W. S. Bishopp	New York	373
3. B. J. Griffin	Kentucky	371
4. Albert I. Mann	Massachusetts	361
5. H. H. Hannam	Ontario	359
6. M. L. Paul	Texas	348
7. O. L. Ryall	North Dakota	348
8. Ross Miller	Nebraska	341
9. T. Martell	North Dakota	339
10. F. J. Arnold	Iowa	335

Individuals

Guernseys

1. D. M. Seath	Iowa	375
2. F. J. Arnold	Iowa	375
3. C. N. Dotson	Oklahoma	375
4. O. F. Garrett	Illinois	360
5. C. L. Blakeslee	Minnesota	360
6. R. Goley	Oklahoma	360
7. R. K. Mitchell	New York	355
8. H. L. Peterson	Texas	355
9. C. W. Thole	Kansas	355
10. G. Bowman	Virginia	350

Individuals

Holsteins

1.	C. L. Blakeslee	Minnesota	370
	Holstein-Friesian Scholarship $400		
2.	E. Bartle	S. Dakota	365
3.	R. K. Mitchell	New York	335
4.	D. M. Seath	Iowa	335
5.	D. E. Borror	Oregon	329
6.	A. I. Mann	Massachusetts	325
7.	C. W. Sadd	New York	325
8.	C. E. Williams	Tennessee	325
9.	D. R. Williams	Massachusetts	325
10.	O. F. Garrett	Illinois	325

Individuals

Jerseys

1.	J. E. Craig	Wisconsin	380
	AJCC Scholarship $400		
2.	D. M. Seath	Iowa	375
3.	L. F. Steiner	Ohio	375
4.	R. C. Ferguson	Iowa	369
5.	T. M. Miller	Indiana	367
6.	G. H. Faulconer	Kansas	365
7.	O. F. Garrett	Illinois	363
8.	R. E. Horwood	Michigan	362
9.	M. L. Paul	Texas	361
10.	A. E. Skidmore	Oregon	360

Individuals

All breeds

1.	E. Bartle	S. Dakota	1380
	Gold Medal—National Dairy Association		
	Cane—Dairy Farmer		
2.	D. M. Seath	Iowa	1365
	Silver Medal—National Dairy Association		
	Cane—Dairy Farmer		
3.	O. F. Garrett	Illinois	1361
	Bronze Medal—National Dairy Association		
	Cane—Dairy Farmer		
4.	C. L. Blakeslee	Minnesota	1343
5.	G. H. Faulconer	Kansas	1341
6.	R. C. Ferguson	Iowa	1338
7.	W. S. Bishopp	New York	1327
8.	R. H. Smith	S. Dakota	1317
9.	F. J. Arnold	Iowa	1313
10.	W. N. Wehr	Ohio	1304

Teams

Ayrshires

1. Kentucky..... 1001
   Ayrshire trophy—Ayrshire Breeders Association
2. Ontario..... 995
3. Ohio..... 986
4. Texas..... 984
5. Massachusetts..... 979
6. North Dakota..... 967
7. New York (Cornell)..... 951
8. South Dakota..... 951
9. Kansas..... 947
10. Iowa..... 944

Teams

Guernseys

1. Iowa..... 1090
   Guernsey trophy—American Guernsey Cattle Club
   Guernsey placque—American Guernsey Cattle Club
   Book Ends { R. C. Ferguson; D. M. Seath; F. J. Arnold; C. T. Peterson (Alt.); Prof. F. Ely (Coach) }
2. Oklahoma..... 1045
3. Kansas..... 1025
4. S. Dakota..... 1015
5. Minnesota..... 990
6. Cornell..... 980
7. Illinois..... 980
8. Ontario..... 975
9. Nebraska..... 940
10. Missouri..... 935

Team

Holstein

1. S. Dakota..... 985
   Holstein trophy
2. Cornell..... 970
3. Illinois..... 946
4. Oregon..... 931
5. Iowa..... 913
6. Purdue..... 909
7. Minnesota..... 885
8. North Dakota..... 873
9. Wisconsin..... 871
10. Massachusetts..... 870

Team

Jerseys

1. Iowa 1069
   Jersey trophy
2. Ohio 1039
3. Illinois 1015
4. West Virginia 1013
5. Kentucky 993
6. Michigan 992
7. Oklahoma 989
8. Virginia 983
9. S. Dakota 976
10. Texas 974

Team

All Breeds

1. Iowa 4016
   Trophy—N. D. A.
   Trophy—Hoards Dairyman
2. South Dakota 3927
   Wyandotte cup by J. B. Ford Company
3. Cornell 3841
4. Illinois 3820
5. Ohio 3800
6. Kansas 3754
7. Kentucky 3726
8. Minnesota 3710
9. Texas 3695
10. West Virginia 3671
11. Ontario 3662
12. Oklahoma 3651
13. North Dakota 3596
14. Missouri 3585
15. Nebraska 3581
16. Wisconsin 3569
17. Tennessee 3562
18. Massachusetts 3551
19. Michigan 3529
20. Purdue 3514

NEWLY ELECTED OFFICERS OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The result of the mail ballot taken in December, 1925, shows the election of the following officers of the American Dairy Science Association for 1926.

President, O. E. Reed ..... East Lansing, Michigan
Vice-President, H. F. Judkins ..... Amherst, Massachusetts
Editor, J. H. Frandsen ..... Lincoln, Nebraska
Secy-Treas., G. C. White ..... Storrs, Connecticut
Rep. to National Research Council,
L. A. Rogers, Bureau of Dairying, Washington, D. C.